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Demand side management options for Sustainable power development

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DEMAND SIDE MANAGEMENT OPTIONS FOR SUSTAINABLE POWER DEVELOPMENT

BACKGROUND

The traditional approach of bridging the demand supply gap through an increase in the installed capacity has mainly two limitations. It requires investment of huge financial resources and also has an adverse impact on the environment. Also, India is presently facing an energy shortage of 5.9% and a peaking shortage of 12.2%. The peak demand requirement, availability and shortfall for the last ten years have been tabulated [1]below:

Year	Peak Demand		Shortfall	
	Requirement (MW)	Availability (MW)	(MW)	%age
1990-91	44,005	37,171	6,834	15.5
91-92	48,055	39,027	9,028	18.8
92-93	52,805	41,984	10,821	20.5
93-94	54,875	44,830	10,045	18.3
94-95	57,530	48,066	9,464	16.5
95-96	60,981	49,836	11,145	18.3
96-97	63,853	52,376	11,477	18.0
97-98	65,435	58,042	7,393	11.3
98-99	67,905	58,445	9,460	13.9
99-Jan. 2000	70,321	61,712	8,609	12.2

This shortfall is being experienced because capacity addition achievements have fallen short of the requirements. Capacity addition[2] during the eighth five year plan was only 16,422 MW against a target of 30,538 MW and capacity addition during ninth five year plan is going to be around 20,097 MW against a target of 40,245 MW.

In addition, electricity energy consumption has been growing at an average rate of around 6-7 %[3]. Increasing financial resource crunch coupled with the fact that there is a global pressure to limit environmental impacts, sustaining this level of energy consumption is not feasible. An improved efficiency of energy utilization has been thought of as an alternate cost effective way to reduce the gap between the produced and the demanded power and limit the environmental impacts of energy generation, conversion and use thereby contributing to **Sustainable Development.** This approach which concentrates on reducing energy consumption at the end user's premises is known as **Demand Side management (DSM).** Integration of DSM and supply side resources can result in cost savings, reduced emissions and improved reliability of electric supply.

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[1] G M Division, Central Electricity Authority (CEA)
[2] IRP Division, CEA
[3] DMLF Division, CEA

a. AIM OF THE PROJECT

To study the various DSM options and their application to electrical energy systems.

b. OBJECTIVE OF THE STUDY

1. To comprehensively review the methods of DSM being practiced by various electri utilities in India and abroad.
2. To apply some of the DSM techniques to reduce electric energy consumption in Delhi

c. EXPECTED VALUE TO THE EMPLOYER

Though DSM techniques are not new to the electric utilities in India, still they are n being implemented in a big way. Under Section 3(1)(v) of Electricity (Supply) Act, 194 the responsibility for advising the State Governments, Boards, Generating Companies (other agencies involved in generation or supply of electricity to operate and maintain th power system under their ownership in an improved manner has been entrusted to Centr Electricity Authority (CEA). CEA has recently formed a committee to suggest prope implementation of DSM measures by the electric utilities all over the country. Thi committee would evolve a policy framework for implementation of DSM in the countr As a member of that committee, I am expected to contribute to the deliberations of thi committee. Therefore, it was thought fit to first study the various DSM options availabl and the through a case study show how these options can lead to reduced use of primar energy resources and reduced environmental damage leading to Sustainable Developmen

d. METHODOLOGY

The various DSM options available are:

- Load Management
- Improvement in end-use efficiency
- Differential pricing

These options have first been carefully studied. An attempt has then been made to appl them to the power system of Delhi through a case study.

For applying Load Management techniques to the system of Delhi, the hourly load dat (for both the summer and the winter season) of the entire system of Delhi and that of th major categories of consumers was collected from Delhi Vidyut Board (DVB). Th hourly load shapes were then plotted to identify the categories contributing to the syster peak. It was then analyzed as to how the contribution of these loads to system peak can b minimized.

The appliances and equipment being used by various categories of consumers in India ar generally very low in efficiency. Measures which can be taken up by the variou organizations involved which can promote the indigenous availability and extensive use o energy efficient equipment in India have been suggested. Through the case study, th impact of using energy efficient devices on energy consumption has been brought out.

The tariff structure adopted by most of the utilities in India is such that the energy charge remain the same throughout the day and also throughout the year. The different pricin options which can encourage consumers towards energy conservation and off-peak energ usage have been studied and some of the ways in which the existing tariff structure o DVB can be easily modified have been suggested.

The T&D losses [2]in the country are around 24.44%. The loss figures for some of th utilities like Haryana(33.04%), Jammu & Kashmir(47.48%), Andhra Pradesh(31.76% DVB(46.86%) are much more than the optimum value. Such a high value of T&D losse further increases the demand supply gap. Possible causes for a high percentage of T&I losses in DVB system have been identified and measures suggested for reducing the same

e. OUTLINE OF THE PROJECT

Chapter 1 'Introduction'

Chapter 2 'Load Management as a DSM strategy'

Chapter 3 'End Use Energy Efficiency as a DSM strategy'

Chapter 4 'Differential Pricing – A DSM option'

Chapter 5 'Customer Acceptance and Implementation Issues'

Chapter 6 'DSM options for Delhi-A Case Study'

Chapter 7 'Conclusions'

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[2] Provisional for 1997-98, DMLF Division, CEA

CHAPTER 1

INTRODUCTION

Electricity has two particular characteristics:

- Once the supply is made available at the premises of the consumer, power can be drawn by him to the extent of the capacity of the supply lines and equipment without the supplier being able to restrain the quantity except by methods which can totally cut off supply.
- It has to be utilized as it is produced i.e. electricity produced at one time cannot be stocked to be utilized at another time.

These two factors are responsible for the twin related problems of energy/demand and generation management. In recent years, with growing energy costs through increases in fuel prices etc. as also higher investment costs involved, considerable thinking has been done on the subject of feasible methods of energy/demand management in addition to generation management. Demand Side Management strategy also known as the sustainable world energy strategy has the following main features:

- Involves action on the demand i.e. customer side of the electric meter either directly caused or indirectly stimulated by the utility.
- Based on the actual uses for which energy is needed and the ways in which the needs could be most efficiently met rather than on the traditional pre-occupation with energy supply and aggregated demand.
- Includes those activities of a utility aimed at all or a subset of the utility's customers, which are designed to encourage customers to modify their patterns of electricity usage including the timing and level of electricity demand so as to more closely match with the available supply.
- Includes educational activities designed to modify customer consumption and appliance purchasing behaviour, as well as activities to improve the efficiency of the utility's own system
- Involves a partnership between the utility and its customers with resulting benefits to customer, utility and society as a whole. Customers benefit by being better able to control energy use and lower operating costs and the utility benefits because it maximizes productivity and cost effectiveness of a utility's resources.
- The cost of DSM measures per unit of power saved is generally less than the cost to build and operate a new power plant as is obvious from the following:

  Considering changeover from 1 million GLS 60 W to electronic CFL 11 W:

  Load demand with GLS 60 W (p.f. = 1.0) = 60 MVA
  Load demand with electronic CFL 11 W (p.f. = 0.6) = 18 MVA
  Demand reduction = 42 MVA
  Assuming that 50 % of electricity produced is lost in consumption in auxiliaries, T&D losses etc., this demand reduction of 42 MVA is equivalent to 84MVA of installed generating capacity

Cost of constructing 84 MVA thermal power plant @ Rs. 4.5 crores per MVA = Rs. 378 crores
Price of 1 million electronic CFL = Rs. 40 crores
Investment saving per million GLS points = Rs. 338 crores
Demand reduction on power grid = Immediate
Environmental benefits = Immediate

- Constraints experienced in implementation of DSM are lack of knowledge about conservation of energy, lack of incentives to the organized sector to changeover to more efficient technology, non-remunerative tariff particularly in the agricultural sector, pilferage and theft of energy, relatively high cost of new technology etc.
- Apart from giving wide publicity for promoting the use of energy efficient devices, reduction in cost, taxes and duties of energy efficient devices, modification of agricultural pumpsets, stress on use of ISI marked pump sets, co-generation as well as energy audit would be needed for giving the much needed thrust to energy conservation activities.
- Since the implementation of energy efficiency options by customers is limited by a number of technical, economic and financial constraints and barriers, the need for utility action through DSM programs is, therefore, becoming increasingly evident and DSM concepts and techniques, originally developed in USA and Canada are being considered for potential applicability in other countries.
- DSM measures alone can meet a country's future power needs. The only viable strategy for bringing a better balance between the produced and demanded power is for the utilities to intelligently integrate the traditional planning and operation of power production facilities with the emerging concept of actively influencing the demand for electricity.

The various DSM options i.e. Load Management, Improvement in End-Use Efficiency and Differential Pricing have been discussed in the following chapters.

CHAPTER 2

LOAD MANAGEMENT AS A DSM STRATEGY

INTRODUCTION

The electrical power industry throughout the world has developed under the notion that a power system will supply its customers with whatever amount of power they wish to purchase at whatever time they desire. In exercising their preferences, customers have evolved electric power use pattern which displays considerable variability with time of the day, day of the week and season of the year. A typical load curve will have some minimum load, some valley and some peak. The problem of non-uniform demand with the demand substantially higher than the average demand during certain periods and the demand exceeding the supply during certain other periods would inevitably result in break-down of some component or the other. Due to the need of simultaneity of generation with demand, generation facilities have to be built up to cater to the maximum need. The generating capacity of a power system must exceed peak demand by enough margin to handle most emergencies.

The aggregated demand of the consumers varies at various times of the day and in various seasons in accordance with the factors of human activity and environmental factors such as temperature, rainfall etc.. A maximum value of demand would occur depending on location, season, industrialization, mix of the various categories of consumers etc.. One convenient index of the amount of variability in load over a specified time is the ratio of average power to peak power delivered during that time. This ratio is known as load factor. In India, the average load factor is around 60%.

Electric power can usually be produced most efficiently if fluctuations in the total system load are kept as small as possible, that is, if load factors are kept high. In order to cater to the uneven load over a day, week or season, electric utilities have evolved a number of types of generating facilities which are used together in various combinations to minimize total cost.

Electric load management is the concept of altering the customer's electricity use behind the meter. Load management has the purpose of improving the effective utilization of the generating capacity and encouraging the best use of electricity by all consumer categories. Besides it will decrease outage time and result in better customer service. By controlling the detachable load at the customer's premises, the load curve can be levelled out. In that way, power production with low efficiency generators can be minimized and many outages avoided. The peak load reduction can make it possible to postpone the building of new power stations. In this way, considerable savings can be attained. Likewise, reinforcements of high and low voltage networks can be delayed and result in additional savings. The rate of efficiency can vary considerably for power plants of different types and different age. Load control makes it possible to reduce power consumption at times when units with low rates of efficiency have to be in operation. In this way considerable savings can be obtained. The scope of load management includes planning, development and implementation of programmes whose objective is to actively shape the daily and seasonal electric load profile of customers so as to result in better overall system utilization and lower overall costs. Load management programmes are designed to influence customer use of electricity in ways that would produce desired changes in customer purchasing. The objective is to shape future demand for electricity in ways that are mutually beneficial to both customers and utilities.

Load control or load management by use of control devices is a means by which the operation of a consumer's end use equipment may be altered to change the maximum demand and thus the diversified demand experienced by the utility system. Application of this technique generally assumes that the customer has either given permission for supervisory control or has instituted control based on economic motives. In either case, incentives in the form of rates are usually necessary. The objects to be controlled are normally air conditioners, space heaters, water heaters and irrigation pumps. Industrial loads also can be controlled provided they can be switched off or reduced for some time without disturbing the production. A load control system can also be used for a number of additional functions such as control of street lighting and in an advanced form for remote reading of meters and monitoring of tampering.

Load control can be categorized in different ways. The first way is that the customers may control their loads voluntarily by altering the use of equipment in response to price signals and the second way is that the utilities may control customer's loads utilizing a signal activated either remotely or at the point of use. Regardless of whether the control device is remotely or locally operated, its impact on the load profile is generally similar for each control scheme. Electricity Boards in India most often use direct control to reduce the peak demand by de-energizing a section or feeder and restricting it to serve in a predetermined duty pattern. Some of the load control systems use the distribution network as communication link while others use radio systems. Control techniques are used with the purpose of optimizing existing capacity. Control techniques can be classified as : Direct load control techniques, Local load control technologies and distributed control technologies:

1. **Direct load control techniques** - In direct load control techniques, the utility controls the customer loads without customer interaction. The most widely used direct control technology is the power line carrier or ripple control system which is used in Europe to shed remote customer loads such as space heating and water heating. After this technology was installed, additional applications for its use were found which include implementation of TOU rates. Some utilities use ripple control to send signals to industrial consumers with which they have DSM agreement.
2. **Local control technologies** - The use of local control technologies allows customers to control the loads. In countries such as France and Italy, the utilities install a circuit breaker in residential premises, which interrupts the power if the consumer exceeds the contracted power. The consumer has to choose the appliances (namely the large ones), he can connect at the same time. In other countries such as Germany and Switzerland, there are interlocking devices which do not allow connection of several major loads at the same time.
3. **Distributed control technologies** - The use of distributed control technologies allows control over loads by customers in communication with utilities. This type of control is applied mainly with large industrial customers, with whom the utilities have special contracts such as interruptible loads.

APPLICATIONS OF LOAD CONTROL

Various applications of load control include a) Peak clipping b) Valley filling c) Load shedding d) Strategic energy conservation e) Strategic load growth f) Flexible load shape. These have been briefly discussed below:

a) **Peak Clipping** – Peak clipping or reduction of system peak embodies one of the classic forms of Load management. Peak clipping is generally considered as the reduction of peak load by means of direct load control. Direct load control is practised by direct utility control of customer' appliances. In an electric power system, the load conditions vary considerably during the 24 hours. There are also variations due the day of the week. Many customers have appliances which can be switched off for a certain time without causing much inconvenience. By switching these objects off and on, the peaks in the day time can be reduced. The load reduction can vary considerably for different types of customers and so it has to be calculated individually for each category of users. In each category of consumers, a detailed analysis of peak clipping possibilities have to be carried out. The relative peak clipping potential will be more in certain types of industries while it will be less in certain continuous process industries. The ceiling demand required to be imposed on each unit should be worked out in consultation with the participating industry and the time period required for this which when arithmetically summed up should not exceed the power availability forecast for the cluster during that period.

b) **Valley Filling** – Valley filling that is building the loads during off peak periods may be advantageous when incremental costs are less than the average cost of electricity. Adding load at the right price can reduce the average cost of electricity to all consumers and improve system load factors. During nights, there is normally a surplus of generating capacity. By utilizing this capacity, the economy could be improved. This is realized by switching off certain appliances such as water heaters, irrigation pumps during day time and on during night time.

c) **Load Shifting** – Loads can be shifted from peak to off-peak periods without changing the overall energy consumption.

d) **Strategic energy conservation** in reference to load management is to use energy efficient equipment and processes that reduce the wastage.

e) **Strategic load growth** are the loads which may produce a general increase in sales beyond any increase from valley filling. This may be accomplished by increasing the market share of loads that are or can be served by other fuels as well as general economic development.

f) A **flexible load shape** means the utility is allowed to adjust the load shape to meet the reliability constraints. This may be done by offering the customers price incentives in return for reduced levels of service. The most common reduced levels of service are-interruptible or curtailable service imposition of devices that limit the power and energy that individual customers can draw.

GUIDELINES FOR OPERATION

A basic guiding factor for applying load management techniques should be to minimize inconvenience to the customers when the demand must be reduced. So, manual load shedding should be avoided as far as possible. Instead load control should be applied. A priority list should be established for switching off the various categories of consumers e.g.

1. Electric signs, floodlighting of buildings
2. Domestic consumers
3. Hotels, offices
4. Small industrial consumers
5. Large industrial consumers

If it is not possible to reduce the demand sufficiently with load control, then manual load shedding must be applied as a complement. The control of various load groups should be rotated to minimize the off time of the individual customers.

Load management is a very effective means to improve the economic rationality of the bulk system which appears mainly as the improvement of various load factors. As soon as load management is performed on a larger scale, it requires a system for the utility to inform the customers; the cost of this system is largely compensated for by the profit made on investments and operating costs. The implementation of a load management system needs a good permanent knowledge of the whole bulk system (generation, network consumption). The solutions best adapted to the generation, electric network and consumption must be chosen. The size of a load management system would be very different between two countries one having means of production with highly contrasted costs and the other with a homogenous generation system. The shape of the load curve also has an influence. Load curve with a very sharp peak would make load management very attractive. The nature and volume of loads that can be modulated also vary greatly from one country to the other.

Introduction of a load management system must be presented by a careful market analysis followed by cost benefit calculation. If the result of the investigations are positive, the customers should be informed about the benefits of the system and be well prepared for coming activities.

INTERNATIONAL EXPERIENCE WITH LOAD MANAGEMENT

The importance of DSM and load management was recognized in USA as early as 1973. The loads involved are water heating systems, central air conditioning systems and space heating systems. More and more utilities are going in for DSM programs. The types of control used are direct control, local control and distributed control. It has been reported that because of load control methods in USA, the average reduction in load ranges from 1kW/point for winter water heaters to 28.7 kW/point for irrigation pumps. The utilities in Canada are not as dependent on oil fuels for electrical generation. Yet load management activities have been put into practice in many provinces in Canada especially in Quebec and Ontario. Load management schemes have been reported to be in operation in Australia, New Zealand, Italy, France, England, Germany, Switzerland and many other countries. Home automation systems in which all home appliances communicate between themselves and are controlled in an integrated manner have been developed. It has been reported that in France, off-peak hour electric consumption has grown considerably due to load management methods partly due to the application of load management techniques and partly due to the price incentives given by the utilities to the customers.

CHAPTER 3

END USE ENERGY EFFICIENCY AS A DSM STRATEGY

INTRODUCTION

Energy efficiency or conservation programs constitute one of the most important part of DSM strategy. It directly reduces the customer's consumption of energy thereby reducing his monthly bills. Secondly, cost effective conservation options reduce overall revenue requirement of the utility and serves to reduce the rates of all customers. Because of the emphasis on the uses to which energy is put, it is also known as an end–use oriented energy strategy. The end–use oriented approach considers the various alternatives of an improvement in the end-use efficiency as well as conventional technologies to arrive at an optimal mix. This approach leads to an identification of an energy future that is much less capital and resource intensive and less expensive overall and more environmentally benign. Large savings in energy efficiency can be achieved in the following areas :

- Agricultural pumping systems
- Metering of agricultural pumpsets
- Use of fluorescent fixtures instead of incandescent fixtures in new construction
- Improved O&M practices in industrial sector
- Development and promotion of efficient end use equipment including motors, variable speed drives, compact and fluorescent lamps, electronic ballasts and domestic refrigerators and other appliances.

EXISTING PROGRAMMES AND POLICIES

The Ministry of Power is the nodal ministry for coordinating efficiency and conservation activities and initiatives in the country. The Energy Management Centre is the executive agency of MOP which implements the programmes and policies as well as provides technical advice and support to MOP on matters relating to energy efficiency and conservation. Efficiency related to electricity generation is undertaken by the generating companies and the SEBs, and the activities are coordinated by the Central Electricity Authrity. Energy conservation/energy efficiency has been on the Government's agenda for over two decades. The activities carried out so far include:

- Awareness programmes
- Information dissemination
- Training
- Studies to assess energy conservation potential
- Demonstration projects
- Pilot programmes

These activities had very limited impact. The idea of enacting legislation for mandatory enforcement of energy conservation measures in areas where energy use is far excessive and intensive has been under deliberation for almost a decade. The matter was considered by the Committee of Secretaries and it was felt that a comprehensive legislation on energy conservation could be undertaken only after creating necessary infrastructure, standards, awareness and trained manpower. It was, however, suggested that to begin with , a selective legislation could be resorted to overcome the barriers to energy conservation. Accordingly, the Ministry of Power constituted a Working Group on selective legislation for energy conservation in 1994 for formulation of suitable proposals. The Working Group deliberated on the various aspects and in its report submitted in 1995 observed that a number of strategies including awareness campaigns, training, institutional framework to develop and promote energy efficient technologies/systems/products, research and development, appropriate pricing of energy supplies, fiscal and financial incentives/disincentives etc. were needed for promoting energy conservation. The Working Group prepared a draft bill on energy conservation. The bill was circulated to all the States and other concerned Ministries.

ENERGY CONSERVATION BILL

For creating an institutional arrangement and proper regulatory system, the Government of India is likely to introduce the 'Energy Conservation Bill' in the budget session of the parliament. The Bill provides for rational and efficient use of electricity. Under the provisions of the bill, there is a proposal to create as new organization called Bureau of Energy Efficiency (BEE). The Bureau will be responsible for implementation of policy programmes and coordination of implementation of energy conservation activities. The BEE shall follow a participatory approach and a wide range of consultation with all the concerned including BIS, business establishments, representatives of consumers before setting standards, norms, designating consumers on deciding on equipment, appliances for which labeling would become compulsory. The various standards and norms of energy conservation shall be examined and expanded to cover an increasing number of equipment/appliances, processes and be revised from time to time keeping in view the technological developments and their relevant techno-economic consideration. Other provisions of the Bill relate to:

- Mandatory energy audit for designated consumers
- Training of managerial and operating personnel and establishment of specialized teaching institution
- Devising specific strategies for creation of awareness among industrial, agricultural, commercial and domestic consumers of energy
- Creation of facilities for promotion of R&D of energy conservation technologies
- Need for rational pricing of energy supply
- Making available adequate financial resources for institutional set up and promotion of energy conservation
- Establishment of a regime of fiscal and financial incentives and disincentives
- Laying down of energy efficiency standards for energy consuming equipment and incorporating in the Indian Standards
- Making it mandatory to display on the label the energy consumption parameters of the equipment as specified in this regard
- Phasing out the manufacture of energy inefficient equipment, which does not conform to laid down standards and prohibiting the manufacture and sale of such equipment
- Formulating energy consumption norms for large consumers of energy particularly energy intensive industrial sector

- Promoting co-generation
- Reduction in T&D losses with special emphasis on reduction of commercial losses.

The proposed bill also provides that State Governments in consultation with BEE may create one or more agency to coordinate and regulate matters relating to implementation of energy conservation in the State.

Expansion of Efficiency Programs in High Priority Areas

The largest opportunities for saving electricity fall in three areas: agricultural pumping, lighting in all sectors and improved operation & maintenance and equipment selection in industrial sector. These three areas should receive priority attention. In addition, there is scope for efficiency improvement in equipment such as fans, refrigerators, desert coolers, air conditioners, water heaters etc. These have been briefly discussed below:

Agricultural Efficiency Programs

Agriculture sector accounts for about 30% of the total electricity consumption in the country. Irrigation pumping contributes to a very large extent to this consumption (80-85%) . The current energy consumption in this sector amounts to 92,000 million units of electricity with an estimated population of 12.2 million electric pumpsets. The extent of commercial energy used in the agricultural sector has been increasing rapidly in the past decade. Also, about 3-4 lakh pumpsets are being added every year in the country. Keeping this in view, agricultural pumpsets represent one of the largest efficiency opportunities in India. Measures which can improve the efficiency of energy use by agricutural pumpsets have been analyzed below:

1) Metering of agricultural pumps
2) Rectification of existing agricultural pumps
3) New high efficiency pumpsets

Metering of Electricity to Irrigation Pumps

Presently in India, the agricultural electricity prices are highly subsidized. The agricultural pumpsets are not metered. Users pay a fixed amount depending upon the pump size, regardless of how many hours the pump operates. Such a system provides no incentive to the users to limit pump operating hours nor to improve efficiency resulting in a lot of water and energy wastage. Also, in many states, agricultural consumers are charged on the basis of the H.P. of the agricutural pumpsets. In India, it has become a common practice that the name plate rating of the set is lower than the actual one because the electricity bill is based on the name plate rating only. This practice also leads to a lot of wastage of energy and huge loss to the utilities.

However, ending agricultural subsidies is a highly charged political issue and is unlikely to happen in the near future. However, if meters are installed at agricultural consumers' premises and they are charged for each kWh they use and the agricultural electricity is priced at the cost of service, substantial wastage of electrical energy would be reduced.

Rectification of Existing Agricultural Pumps

Majority of the existing electric pumping systems currently in operation are inefficient and consume 50% to 100% more electricity than optimum, mainly due to improper selection of the pump and usage of inefficient and sub-standard accessories. Pump performance is a controllable factor and has a bearing on energy consumption. If the various components of the pumping system are not properly integrated as per the requirements, the efficiency of the pumping system could drop down substantially resulting in excessive energy consumption. Various field studies[1] conducted in the country on inefficient agriculture pumping systems indicate that it is possible to enhance the efficiency of the pumping systems through comprehensive rectification programme and save upto 50% electricity.

New High Efficiency Pumpsets

If agricultural electricity use grows by about 80% (from 2000-2010), the majority of pumpsets in use in 2010 would be a combination of new pumpsets and replacement of worn out pumpsets. If at the time these pumpsets are purchased , only efficient equipment is used, savings of approx. 20% can be achieved relative to the typical system being purchased today.

Lighting Systems

Lighting systems account for approx. 13-14% of total electricity consumption in India and contributes significantly higher during morning and evening peak hours. With increased urbanization, construction of more dwelling units, an expanding commercial sector and a massive rural electrification program underway, the demand for lighting is likely to grow rapidly in years to come. In India, four different types of lighting systems are widely used-incandescent, fluorescent, mercury vapor and sodium vapor. Over 80% of incandescent lighting energy use is in domestic sector, over 90% of fluorescent energy use is in industrial , commercial and miscellaneous sectors and over 60% of mercury and sodium vapor lamp energy use is in industrial sector. Various lighting conservation measures have been discussed below:

Incandescent Lamp Replacements

A conventional Indian 60W incandescent lamp puts out approx. 720 lumens of light, making for an efficiency of 12 lumens/watt. Fluorescent lamps are much more efficient with efficiencies of 50-80 lumens/watt for products produced in India and efficiencies as high as 90 lumens/watt for products produced in developed countries. In addition to efficiency advantages, fluorescent lamps generally have longer lives (5000 hours) than incandescent lamps (1000 hours). A 60 W incandescent lamp can be replaced by a 18 W TLD (plus 14 W for ballast) saving more than 40% electricity and providing 50 % more light output. There have been further improvements in fluorescent lamps with improved phosphorus coating that results in 5% to 15% increase in efficiency along with good colour rendering.

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[1] EMC-ORG study on 'Improving Efficiency of Agricultural Pumping System for Energy Conservation', 1992-93

In India, most of the fluorescent lighting is at 40 W plus a 12-15 W magnetic ballast. A better version of fluorescent lamp is also available in India i.e. TLD – 36 W thin tube light. Thus thin fluorescent lamp delivers 10 % extra lumen compared to 40 W fluorescent lamps.

Replacement of magnetic ballasts by electronic or low loss ballasts

The losses in the conventional ballast are about 12 – 15 W compared to 1-4 W losses in the electronic ballast. The electronic ballasts have better power factor and longer lives (20 years) than ordinary ballasts (5 years). However, the cost of a magnetic ballast is Rs. 60.00 while that of an electronic ballast is Rs. 310.00. Low loss ballasts are electro-magnetic hybrid ballasts and have losses in the range of 6-9 W. They are priced at Rs. 180.00. Limiting factors in the use of electronic and low loss ballasts are their high cost and these ballasts being very sensitive to fluctuations in the supply voltage. Advantages of electronic ballasts over conventional ballasts have been tabulated below:

Advantages of electronic ballasts over conventional ballasts
1. Tremendous energy saving. 2. Operates over wide voltage range(100V to 265V). 3. Instant start. 4. Easy connections and maintenance free operation. 5. High power factor (> 0.90). 6. No humming sound. 7. Unique auto-sensing device switches off electronic ballast in case of tube failure. 8. Low weight. 9. Consistent lamp life from optimum operating conditions. 10. No overheating and no fire hazard. 11. Special surge suppressor counteracts transients.

Compact Fluorescent Lamps (CFLs)

These lamps have multiple short fluorescent tubes and are nearly the same size as incandescent lamps yet use 60-70 % less electricity per unit of light output and have lives 8 times that of incandescent lamps. CFLs are replacement for incandescent lamps and not for other fluorescent tube lights. The initial high cost of a CFL and the quality of power supplied are major limiting factors to its use in India. The advantages of CFLs over GLS lamps have been tabulated below:

The advantages of CFLs over GLS lamps
1. 31 times higher lumen-hours/watt. 2. 8 times more life. 3. 75% saving in energy for identical lighting effect. 4. Colour rendering similar to GLS or cool daylight. 5. Tremendous saving in future power generation plans.

6. Substantial saving in annual recurring expenses.
7. Very attractive payback period.
8. Cool operation leading to savings in air conditioning costs.
9. Smaller, slimmer and compact luminaires.
10. Possibility of retrofits with adaptors.
11. Excellent for hard to reach areas.

Savings with electronic CFL lamps over its lifetime of 12,000 burning hours						
1.	Electronic CFL	20 W	15 W	11 W	7 W	5 W
2.	Replaces GLS	100 W	75 W	60 W	40 W	25 W
3.	Saving over 12,000 hrs.=(2-1)x 12000/1000	960 kWh	720 kWh	588 kWh	396 kWh	240 kWh
4.	Savings in electricity bills @ Rs. 3 per kWh	Rs. 2880	Rs. 2160	Rs. 1764	Rs. 1188	Rs. 720
5.	Cost of CFL lamp	Rs. 560	Rs. 400	Rs. 394	Rs.388	Rs. 388
6.	Cost of 10 GLS bulbs	Rs. 100	Rs.100	Rs. 100	Rs.100	Rs.100
7.	Net saving per GLS point (4-5+6)	Rs.2420	Rs.1860	Rs.1470	Rs.900	Rs.432

High Pressure Sodium Vapour Lamps

High pressure sodium vapour (HPSV) lamps consume only 50% power as compared to high pressure mercury vapour (HPMV) lamps and only 20% power as compared to incandescent lamps for the same lumen output. The main limitation in the use of HPSV lamps is their low colour rendering index which makes colour discrimination difficult, thus limiting their use. High colour rendering lamps have been introduced but the improvement in colour rendering is at the cost of their efficiency and life. Low pressure sodium vapour lamps have also been introduced which have the highest efficiency as compared to all other types of lamps. However, their applicability is limited because their extremely yellow light makes colour discrimination impossible. Advantages of conversion from HPMV to HPSV luminaires are tabulated below:

Advantages of conversion from HPMV to HPSV luminaires

HPMV	to	HPSV	Remarks
125 W		70 W	30% higher light, 44% less energy
250 W		100 W	Same lighting, 60% less energy
400 W		250 W	56% higher light 37.5%less energy

Pay-back Periods :

	For the Customer	For the Nation
125 W to 70 W	33.5 months	2.37 months
250 W to 100 W	15 months	1.06 months
400 W to 250 W	20 months	1.41 months

Comparison of LPSV vs. HPSV lamps		
	LPSV 135 W	HPSV 250 W
Luminous Flux	23,000	26,500
Utilization Factor	0.25	0.35
Effective Lumens	5,750	9,275
Total Circuit Wattage	163 W	280 W
Effective lumens/ W	32.276	33.125
Economical life in burning hours	10,000	15,000
Effective kilolumen-hours / W	322.76	496.875
Overall efficiency		+ 40.85%

Other options

Programmable timers/photo cells can be introduced at suitable street lighting locations. These timers/photo cells would ensure that the street lamps would automatically get switched off and on during day and night time respectively. The timers can be adjusted to suit the varying day light hours of summer and winter.

High efficiency fans

Fans are the major users of electricity during the summer months. The efficiency of a fan can be improved by the use of more efficient motor and electronic speed control. The efficiency of fan motors can be improved by 10-15% with a 30% price increase by using aerodynamically designed fans and improved impeller designs. Most of the Indian fans use resistance type speed regulators which have energy loss in the form of heat thus reducing their efficiency. Electronic regulators reduce energy losses by 10-20% when fans are operated at low speeds. However, it has been found that electronic controllers used in India introduce harmonics thereby reducing the power factor.

Refrigerators

The efficiency of refrigerators used in India is very low. A typical 165 litre Indian refrigerator consumes approx. 540 kWh per year whereas a 200 litre Korean model uses approx. 240 kWh/year. Efficient refrigerators can save 30-50% energy used, though they have high initial cost. High efficiency refrigerators are currently not available in the Indian market as these refrigerators use a different compressor design which are very sensitive to the quality of power supplied. Till such time as the electric utilities in India can ensure power supply at rated voltage and frequency, any increase in the efficiency of refrigerators can come only through better insulation techniques.

Air Conditioning

Room air conditioners

These often represent the heaviest load for individual households using air conditioners. Therefore even a modest improvement in their efficiency can result in considerable saving for individual consumers, thereby reducing the demand on the system. Efficiency of air conditioners is measured by energy efficiency ratio(EER) which is the BTU of cooling output divided by Watts of power input. BIS calls for an EER of 6.6-7.0 whereas most of the units sold in our country have an EER of 5.0. In U.S., EERs must exceed a level of 8.6 and units with EERs as high as 12.0 are available. In Thailand, units with EERs of 9.0-10.6 are also readily available.

Central AC systems

Efficiency of central AC systems can be increased by carefully designing the buildings to reduce the heat gain into the building, improved thermostat and other controls. Saving in electricity can be achieved by designing the AC system for an ambient of 40.5° C in summer and 10 C° in winter rather than for extreme ambient air conditioning of 43.3° C in summer and 7.2 C° in winter which occurs for only a few days in the whole season. The operation of an AC system should be to provide just comfortable temperature rather than cold temperature. Reliable door closers can enhance the effectiveness of the system by checking the infilteration into the conditioned space.

Desert coolers

Coolers constitute a major electric load during the summer months. A typical cooler uses 20% more electricity than a unit meeting BIS standard. The efficiency of a cooler can be increased by an improvement in the efficiency of the fan motor and that of the water circulating pump. A 20% higher efficiency level can be achieved at an incremental cost of Rs. 500.

Water Heaters

Energy savings in water heaters can be achieved by using better insulation techniques. In hotels, central water heating systems are adopted. Reduction in energy use by these water heating systems can be achieved by covering the tank with an insulating blanket made of fibre glass and backed with vinyl. These blankets reduce the heat loss through the walls of the tank. These blankets can also be used to cover the sides and the top of the water heater. Bottom boards can be used to limit heat losses through the bottom of the tank. Insulation of hot water pipes also reduces heat loss.

Industrial Sector

Industrial sector accounts for approx. 38% of the total electricity consumption in India and motors are the major users of electricity in this sector. Therefore, even a slight improvement in the efficiency of electric motors can go a long way in reducing energy use by this sector. Some of the measures which can be taken for reducing the demand of the industrial sector are:

High Efficiency Motors

High efficiency motors produced in India are 2-5% more efficient than standard efficiency motors. Indian manufacturers do not produce high efficiency motors below 10 HP and above 170 HP. The percentage of high efficiency motors in India is less than 1% because these motors are 25-35% costlier than the standard efficiency motors. Part of the increased cost is import duties on low loss silicon steel which is used in the cores of high efficiency motors. These motors may be introduced when the existing motor wears out and needs to be replaced.

Improved Motor Rewinding, Sizing and Maintenance

It has been observed that motor efficiency in the field is often lower by about 4-13% than the tested efficiency of a new motor in the laboratory. The reasons for the difference include over sizing of motors, phase imbalance, poor rewinding of motors and less than adequate motor maintenance. It has been estimated that motor energy use can be reduced by about 2-3% due to improved repair and rewinding practices, plus some additional savings that are possible from proper motor sizing.

Variable Speed Drives

Variable speed drives (VSDs) are electronic devices that are placed between the motor and the power supply. VSDs can continuously vary the speed of a motor from 100% down to very low speeds. In addition to energy savings, VSDs offer a number of other advantages such as improved equipment lifetimes, better process control and product quality and operation at higher speeds than standard line frequencies allow. Presently VSDs are quite expensive in India which is limiting their use.

Maximizing Co-generation

In the process industries, when the heat to power ratio becomes favourable for co-generation of steam and power, it offers economic option for meeting not only captive power requirements but also export excess power. Sugar, paper, textile, fertilizer, cement, chemicals and pharmaceutical industries offer a good scope for adoption of co-generation. High initial investment and utility policy are the main barriers to implementation of co-generation in India. However, with the change in Government policy, increasing need being felt for augmenting power availability and economic feasibility of using non fossil fuels, there is now a favourable climate for promoting co-generation of electricity in India.

INTERNATIONAL EXPERIENCE IN END-USE EFFICIENCY

Efforts to introduce efficient devices and to educate consumers about their use have been undertaken in many countries of the world. Many new technologies for energy saving have been developed in USA, Germany, Japan and other countries. It has been reported that due to use of more efficient devices in USA during 1990-93, the average consumption in refrigerators decreased from 950 kWh/year to 504 kWh/year. Similarly for deep freezers, the annual energy consumption fell from 1100 kWh/year to 835 kWh/year. Many end-use efficiency programmes including co-generation, promotion and sale of energy efficient devices energy audit, appliance efficiency labelling etc. have been initiated and implemented in Australia. It has been reported that in Germany, the electrical consumption has decreased by about 20% for washing machines, 30% for dish washers and 45% for freezers during the past 15 years. In Sweden, an improvement in the end-use efficiency methods have resulted in reduction in energy consumption by referigerators from 1.4 kWh/litre/year to .9 kWh/litre/year. Similar reduction in energy consumption by various appliances have been reported from UK, France, Japan and many other countries.

CHAPTER 4

DIFFERENTIAL PRICING-A DSM OPTION

INTRODUCTION

According to modern economic theories, the most important function of prices is to contribute to an efficient use of utility's resources. To achieve this objective, buyers of electric power should receive correct information about the cost of delivering that power. The utilities then receive information about the willingness of consumers to pay for the power through the development or demand for the power. Prices should also lead to a balance between supply and demand, so that allocation mechanisms such as queues and rationing(load shedding) normally may be avoided. The first cost concept for pricing of electric power was based on the average total costs of the utility. It was easy to understand that the total costs had to be covered by income from sales. However, these tariffs gave no relation to efficient use of utility's resources.

The ultimate aim of load management is to reduce the average cost of electric power. To achieve this objective, load control through pricing could be applied to obtain an improvement of load factor, a reduction in the need for peaking capacity and a higher utilization of the generating units. A properly designed tariff can contribute to reduce the peaks and fill up the valleys. This would reduce the need for load shedding and also improve the service to the consumers.

The guiding principle for the design of tariffs should be that each consumer category should be charged for its contribution to the total costs for generation, transmission and distribution of electric power. However, in India, the energy price structure has been formulated in such a way that the electricity supply to agricultural and low income residential consumers is highly subsidized. These prices therefore do not reflect the true cost of power generation, transmission and distribution. The pricing of energy below its cost sends an inaccurate signal of the value of energy to the consumer. Tariff structure can be used as a means for achieving DSM objectives because customers respond to electric bills by changing their level and patterns of usage. The exact magnitude of customer response to alternate tariff structures cannot be predicted with great accuracy, but the customers respond in a generally predictable way to alternate rate structures.

Through appropriate pricing signals, consumers can be encouraged to recognize that electricity is not easily stored and that generating costs may vary considerably across the load curve as increasing demand is met from (relatively cheap) base load plant to (relatively expensive) peak duty generating plant. A properly devised pricing policy can defer investment in new generating capacities by creating incentives for the consumers to shift load from peak hours to off peak hours as well as inducing consumers to invest in energy efficient measures.

The cost of supplying an additional unit of power varies with time of day and season. Generally, a customer is charged per unit of energy at all times of the day at the same rate. The variation in the cost of production over a time period is not reflected in the rate charged from the customer. Marginal cost based tariffs send the right price signal to a utility's consumers which helps them make appropriate decisions when deciding on the purchase and use of electricity using equipment and appliances. Marginal cost of power supply is defined as the change in the total cost of service resulting from small changes in demand. This cost may change according to the place and time of use (TOU). Marginal costs are a reflection of the economic costs incurred by a utility to meet additional demand in capacity and energy. These type of tariffs not only cover the historical costs, but also provide a revenue that is high enough to cover the incremental costs arising from new investments – from power plants to distribution lines – needed to supply the extra demand. Marginal cost based tariffs based on TOU provides the utility with some leverage to control future load growth and load shape and therefore used as a load management tool in DSM programmes.

PRICING OPTIONS

Pricing options for shifting demand from peak to off peak hours and also some of the pricing options for promoting energy conservation have been discussed below:

Time of Day or Time of Use pricing

The technical development of metering equipment has made it economically possible to measure energy consumption during different times of day (TOD), days of week and periods of the year. TOD rates make electricity more expensive when it costs more to generate additional electricity i.e. during the utility's peak hours and cheaper during off peak hours. Such a type of rate structure would encourage customers to shift their load, whenever possible, from peak to off peak hours, thereby flattening the load curve. This would be favourable to the customers who would find their bills reduced and also favourable for the electric utility who would gain by a decrease in the peak load.

Such rates should be offered to all classes of customers, generally on a voluntary basis to the residential consumers and on mandatory basis to large commercial and industrial consumers. Such a type of pricing option is possible only if the electricity meters installed at the consumers' premises have an in built timing unit. Since the cost of TOU meters in India is still very high, such a type of energy pricing has only been introduced for selected HT industrial consumers at present and that too in some of the States.

Seasonal Tariff Pricing

This is a variation of TOU tariff because under this pricing scheme, The tariff rate changes across seasons. This type of tariff pricing offers an economical way of managing demand. Since the peak months are fairly stable, the tariffs can be adjusted to reflect seasonal demand variations. That is to say that the tariff is structured in such a way that it costs more to use energy during certain periods of the year than at others. This system has certain advantages over TOD metering. Since it dispenses with the need for expensive meters needed under TOD system, no significant capital expenditures are required. The tariff is so structured that it costs more to use energy at certain times of the year than at others. For this, the consumers' billing frequency has to be synchronised with the time when the seasonal rates come into effect.

Curtailable/Interruptible (C/I) rates

C/I rates credit customers for reducing demand, upon notice from the utility, to a predetermined level. Owing to the nature of service,. these rates are primarily aimed at industrial and commercial consumers. The success of such a system depends on the reliability of the communication system and the ability to respond on the part of consumers to communication signals.

Pro-rata tariff for agriculture

Electricity to the agriculture sector is heavily subsidized not covering even the cost of supply. Moreover, the electricity tariff for the agriculture sector is based on the rated capacity of the irrigation pump and not on the actual consumption. Hence there is no incentive to save energy or water. Pro-rata tariff for agriculture consumers should be introduced. However, the biggest obstacle in altering tariff rate and structure is the strong farmer lobby in the agriculture sector.

Inverted Tariff Structure

A rational system of tariff is the block meter rate. In this system, the consumers are charged on a sliding scale. A certain unit rate is charged for a certain block of energy, the corresponding unit charge decreases. Generally, the energy consumption is divided into three blocks. This tariff structure was proposed to encourage the use of electricity. This was based on the assumption that an increased electricity energy usage leads to an overall lower cost of generation for the utility and therefore the benefit of lower generation cost should be passed on to the consumers.

However, because of the necessity to reduce energy consumption, inverted tariff structure is in practice for the residential consumers. In this structure, the unit energy charge increases with increase in energy consumption. The total energy consumption is divided into 3-4 slabs. The unit energy charge for each succeeding slab is about 50-75% higher than the energy charge for the previous slab.

PRICING OPTIONS : SOME INTERNATIONAL EFFORTS

It is an accepted fact that offering incentives and pricing options to customers is the best way to promote DSM. In USA, bill credits range from $1 to $5 per month for water heaters, $1.25 to $12 per month for air conditioners, $1.5 to $29/H.P./year for irrigation. In addition, 7% to 50% rate reductions per kW demand, 8% to 20% rate reduction per kWh and $0.003 to $0.061 per kWh discounts are offered by many utilities. Some utilities offer inconvenience payments of $25 to $150 per year. In UK, for residential consumers differential tariffs are offered. This tariff called `Economy 7` offers electricity during night time at less than half the day time rate. In Ontario (Canada), DSM programs have resulted in annual savings of $83 to $90 per customer. The incentives to customers varies from $27 per month to $48 per month. In France, a 4 time period per day tariff structure has been proposed for small industrial consumers. Similar incentives and multiple pricing options exist in a large number of countries in Europe and elsewhere.

DIFFERENTIAL PRICING - EFFORTS BY INDIAN UTILITIES[1]

Some of the Indian electric utilities have tried to implement differential pricing options for the industrial sector. Some of the examples are given below:

For LT industry

Surat Electricity Company

- TOU(time of use) charges @ 75 paise/kWh for using power between 07-11 hrs. and 1700 hrs. to 2100 hrs.

For HT industry

Surat Electricity Company

- TOU charges for consumption between 0700 to 1100 hrs. and 1700 hrs. to 2100 hrs..
- Demand in excess of C.D.(contract demand) upto 10% of CD @ Rs. 300/kVA/month, remaining excess @ Rs. 500/kVA/month.

Punjab State Electricity Board

- If a consumer in a month exceeds the contract demand, such excess shall be charged at an additional rate of Rs. 150/kVA of first default and Rs. 300 per each subsequent default.

Gujarat Electricity Board

- TOU charge @ 75 paise/kWh for the energy consumption during the two peak periods viz. 0700 hrs. to 1100 hrs. and 1700 hrs. to 2100 hrs. would be levied on consumers having CD/Actual demand of 500 kVA and above.
- Concessional rate of 150 p/unit is admissible for using energy during night hours from 2000 hrs. to 0600 hrs. in excess of one third of total energy chargeable under bulk rate.

Andhra Pradesh Electricity board

- For seasonal HT industries, the rates for declared off season load shall be on the basis of recorded maximum demand or 30% of contracted demand whichever is higher.

Grid Corporation of Orissa

- Penalty for over drawal is levied at the rate of Rs. 90/kVA
  If the maximum demand exceeds the contact demand by 5% during a month, the supply shall be disconnected and shall remain disconnected till the consumer pays the prescribed reconnection charges and undertakes to limit his drawal to the contract demand.

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[1] Council of Power Utilities, Summary of Tariff Schedules of Electric Power Supply Utilities in India (updated upto Sept. 1998).

Ahmedabad Electricity Company

- TOU charges @ 40 paise/unit between 1200 hrs. to 1700 hrs.& 1830 hrs. to 2130 hrs. (April to October) and between 2000 hrs. to 2400 hrs. & 1800 hrs. to 2200 hrs. (November to March).
- For consumption during 1000 hrs. to 1800 hrs. (March to Sept.) and during 1400 hrs. to 2200 hrs. (Oct. to Feb.) – 10 paise/unit.

CHAPTER 5

CUSTOMER ACCEPTANCE AND IMPLEMENTATION ISSUES

CUSTOMER ACCEPTANCE

The ultimate aim of any utility before taking up any DSM programme should not be to manipulate load but to satisfy the customer that is to say that customer satisfaction should be the basis for measuring the success of any DSM pragramme. A utility should put great emphasis on identifying customer problems and resolving them immediately. Through the use of extensive surveys and direct customer contact, a utility should be able to comply with the customer's needs and keep the most important goal in perspective – serving the customer.

Customers' acceptance refers to the customers' willingness to participate in or adopt the programme encouraged by the utility. The choice of appropriate implementation strategies requires the utilities to have sufficient knowledge and understanding of a number of customers' characteristics. Although utilities can offer a wide range of incentives to encourage customer participation in a particular load management programme, it is ultimately the customer's decision to participate that influences the success of the activity. While all DSM programmes differ to some degree, many underlying factors are common to a variety of them and influence the extent to which customers will participate. These factors have been briefly discussed below:

1. **Incentives** : Some programmes offer specific incentives to the customers to participate e.g. in case of a TOD rate programme, customers save on their bills by shifting energy usage.

2. **Marketing** : Many different approaches can be used to attract participants to the programme such as door to door campaigning explaining the programme to the individuals, full scale media programmes to encourage participation etc. It has been experienced that aggressive efforts have a large impact on the participation levels.

3. **Effect on service** : Any programme that affects the desired energy service will have some effect on the customer's decision whether or not to adopt the programme. The customer's acceptance of DSM pragrammes would be better and easier if the programme does not dramatically affect the service provided by the utility. The aim should be that the customer should willingly accept the load management programs and some little change in his lifestyle because of the program.

4. **Consumer expenditure** : It is usually true that the high efficiency equipment needs greater initial investment . Most customers are swayed by low initial cost devices irrespective of their higher O&M costs. This is partly due to customer's inability to pay more initially and partly due to customer's ignorance about high O&M costs. It is imperative that the customers are educated about the life cycle costs (initial cost + O&M cost) of the devices.

5. **Effects on attitudes** : People's attitudes towards the utility, energy use and other basic factors strongly influence whether or not they will be willing to participate in DSM programs e.g. conservation programs are more readily adopted by the consumers as compared to valley filling/load building programs. The consumer attitudes can be altered by changing beliefs, feelings, self-perceptions and social consciousness.

Customer acceptance of DSM programs has not been very successful till now because the energy consumer at present does not perceive a tight connection between behaviour and prices. Encouraging adoption involves at least an improvement in the consumer's information base and helping establish in his mind the connection between specific behaviour and costs. Before introducing any DSM program, the customer must be introduced to innovation, acquire sufficient detailed knowledge of it to make a decision and weigh the decision, assessing risks involved. Thus the consumer must incur costs before deciding and these costs are added to the accounting cost of innovation and transaction costs associated with adopting it. Decisions are costly and one approach to encouraging adoption would be to minimize these costs for the consumer.

The challenge before the utilities is how to use the marketing strategies in the best possible manner so as to convey information quickly to the consumers and change their attitudes towards energy usage. Also specific information, possibly with a focus on negative consequences of inaction, seems to be important in affecting use behaviour. Information must be directed and presented in useful ways. Specific directives such as "shut off lights when leaving" are more effective in assisting behaviour change than generalities such as "conserve energy" which are not translated into action.

Credibility is also crucial to information programmes. Information well packaged and presented by a credible source, might still have limited effect on consumers if it contradicts their irrational feelings and beliefs. People seem to be selective information processors, tending to adhere to information that conforms with existing belief and to filter out other information. Changes that are brought about voluntarily are more stable than coercive changes.

Also there is enough information to support the fact that the decision making process for adoption of DSM programs is more complex in case of commercial and industrial consumers than for residential consumers. The reasons are:

a. The industrial processes to be modified may be more complex than the end uses of energy in a home and may require customized analysis and design rather than off-the-shelf solutions.
b. Decisions may be made by a hierarchy of individuals representing different functions in an organization.
c. The decisions taken by the management may not be acceptable to the work force.

The decision making process is generally bottom up, with each individual in the ascending hierarchy having the right to veto a decision to proceed. Part of a utility program strategy may be to influence attitudes and subsequent decisions by those decision makers who might otherwise provide a potential barrier to a positive decision. In modeling the impact of DSM programs, measurement of management attitudes may be one of the data requirements.

Also participation by certain firms and individuals in DSM programs may induce participation by non-targeted firms and individuals. The non-participants may be influenced directly by some aspect of a DSM program or they may be influenced by the actions taken by participants. Information diffuses most rapidly from individual to acquainted individual and the demonstration effect provides the most credible information to those yet to take the decision. Also in marketing DSM programs, some of the messages are received by non-participants and as a result of advertising, they may undertake the desired behaviour.

IMPLEMENTATION ISSUES

While DSM has been successfully implemented in several developed countries to bring down the level of consumption without affecting the level of outputs in the consuming sectors, its implementation in the developing countries has been limited by a number of technical, institutional and information related barriers, though DSM as a concept is known to these countries. US utilities have been involved in DSM activities for around twenty years, while in Canada the process has started around the mid-eighties. Early DSM efforts tended to focus on audits, simple information programs, direct load control and rate making. More recently, utilities have begun to implement comprehensive programs incorporating a package of energy efficiency measures and multiple marketing and delivery techniques. DSM programs are available for new construction markets as well as for the existing markets. New construction programs can result in a relatively high savings at modest cost to the utilities. The programs for existing market range from simple information programs, audits to retrofit.

DSM programs need not necessarily mean advanced technologies or entire process changes. There are several measures which can be undertaken by consumers which either need marginal investments or in several cases none at all. The need is to bring about increased level of awareness on an urgent basis so as to save energy. It is the end-user who has to purchase, install, use and maintain the energy efficient equipment. Next we have the manufacturer of the energy efficiency equipment. The third group includes the government, financial institutions, testing laboratories, industry associations, consumer forums etc. who can play a significant role in promoting end-use energy efficiency. The final decision of course is with the end-user. All the others facilitate the availability of energy efficient technologies and assist in pushing the end-user into making the final decision.

It is important to note that even some of the most successful DSM programs have achieved at the most one-third of the technical potential (where technical potential is ultimate potential which excludes economic constraints and market barriers). There is a need to identify some of the crucial issues that presently constrain the implementation of DSM programs. The main factors that constrain consumers to move towards more efficient utilization of energy are:

1. **Lack of information**- One of the main constraints in the implementation of DSM programs is information gap. Consumers are usually unaware of the opportunities to improve energy efficiency. Information on energy efficiency of equipment is generally not available and if available is general rather than specific. This problem can be

addressed by more detailed educational efforts customized to each end-use segment, with an emphasis on providing information immediately before the decisions are made. Options include: energy labels on appliances, motors and pumps and training programs for industrial energy measures on specific topics relevant to their industry.

2. **Cost of energy efficient equipment**- Most of the consumers seek to minimize the initial cost of the equipment even though this may result in higher operation and maintenance costs. Costs of energy efficient equipment are generally higher than the cost of standard equipment normally purchased. This also applies to energy efficient equipment procured from outside the country. Manufacturers have an important role to play in developing the market for such equipment. Incentives in the form of reduced excise duties and import duties on the imported raw material or components, loan at concessional interest rates by financial institutions would help bring down the cost of energy efficient equipment.
3. **Pricing** – Most of the developing countries charge some categories of consumers rates below the cost of generation and supply. This does not encourage the consumers towards energy conservation or more efficient end-use. Quite apart from the above innovative pricing mechanism such as TOD rates, interruptible / curtailable rates etc. are not even under consideration. In several developing countries, no data base exists to determine the impact of prices on consumption patterns. This is a major area which can be used effectively to manage demand.
4. **Poor power quality and reliability** – Electricity supply in most of the developing countries is characterized by large fluctuations in voltage and frequency causing damage to the equipment. Because of these fluctuations, voltage stabilizers have to be used by the consumers which add to the load of the system. These fluctuations are mainly due to the shortage of generating capacity during peak periods. In addition, power outages both planned and unplanned are also very common. Some of the consumers use diesel generating sets in case of an outage which impose heavy economic costs on the consumers and are also very damaging to the environment. These power quality and reliability problems impede efficiency measures in several ways. Some equipment cannot be used at low voltage while some equipment consumes more energy at low voltage. Also , if an equipment has to be designed for withstanding wide voltage fluctuations, that equipment would be more costly and generally less efficient. Therefore, the quality and reliability of electric supply has to be improved if DSM programs are to be successfully implemented.
5. **Limited availability of efficient equipment and components** – Many types of efficient equipment are readily not available in India. Examples include efficient refrigerators, room air conditioners and evaporative coolers. While this equipment can be imported, the transportation costs and import duties raises the cost of the equipment to unacceptable levels. Indian manufacturers are often reluctant to produce new equipment because they are unsure of the demand. Also, raw material and components needed to produce efficient equipment are sometimes not readily available indigenously. All these factors must be taken care of if DSM programs are to made successful.
6. **The Small-Scale Sector** – Many types of energy using equipment are manufactured in India predominantly by small scale sector such as ballasts, lighting fixtures, small electric motors and pumps, fans, coolers etc. This reliance on the small scale sector affects the equipment efficiency in several ways. Quality control is generally not very good in the small-scale sector and energy efficiency usually suffers as a result. Rarely does an equipment manufactured by a small scale firm meet BIS standards. Also, small

scale firms compete primarily on the basis of cost and in order to minimize costs, efficiency considerations are generally ignored. This problem can be overcome by providing technical assistance to small scale firms for improving the quality and efficiency of their products. In cases where the small scale sector cannot produce the desired efficiency equipment, the organized sector should be allowed to enter the market.

7. **Used Equipment Market Delays Retirement of Inefficient Equipment** – In India, there is a very large market for used equipment. Broken equipment is generally repaired and is retired only when no further repairs are possible. This results in a very long in-service life for the equipment in India, which means that it would take a very long time for inefficient equipment to get retired. Therefore, efforts should be to target new equipment market. Also, programs should be offered to promote early retirement of inefficient equipment.
8. **Shortage of Skilled Staff** – There is a shortage of skilled staff who can provide technical assistance in identifying, installing and maintaining efficiency measures. Technical assistance capabilities need to be developed through training programs, setting up energy conservation cells etc.

DSM IMPLEMENTATION STRATEGIES

The DSM implementation strategies that can promote customer adoption of high efficiency technologies including air conditioners, refrigerators, fluorescent tube lamps, CFLs, motors, load management programs can be classified into:

1. **Market transformation through voluntary agreement** - The utilities should engage in direct negotiations with manufacturers of various equipment to agree to voluntarily ban production of low efficiency equipment. To start with, utilities should ask lamp manufacturers to ban production of low efficiency incandescent lamps and only produce CFLs and thin fluorescent tube-lights. In return for the agreement, the utilities should finance advertising campaigns in mass media to promote new energy saving lamps. The impact of the program can be substantial as it would result in substantial energy savings and reduction in coincident peak demand.
2. **Energy Efficiency Labelling** - All participating brands of refrigerators, air conditioners, motors, fans, pumps etc. should carry an energy efficiency label that would indicate its efficiency, annual kWh consumption and energy saving estimates. This would make the customers more aware of the link between the efficiency levels of these equipment and the subsequent energy savings (and hence reduced bill) that would inevitably result.
4. **Customer Oriented Program Design** - Each customer has unique energy requirements and financial position. Therefore, the programmes must be flexible so that every customer can be accomodated as per his needs and requirements.
5. **Public Private Sector Partnership** - Design and development of energy saving programmes requires special knowledge for which energy consultants are needed. Those consultants provide the necessary service to the customer for a certain consultancy fee. The utilities should engage consultants to provide such service to the customers and pay them directly.

Program design should consider the significance of the first-cost barrier. If financial incentives are deemed necessary to promote energy efficiency, DSM programme designs should consider that the first-cost barrier is more significant in less developed economies than in developed countries. The incremental cost of procuring high efficiency equipment as a proportion of consumer's disposable income is higher in less developed countries. In such a case, provision of an interest free loan is a more effective marketing strategy than offering a fraction of the incremental cost in the form of rebates.

Establishing a funding mechanism for DSM investments is essential for long term sustainability. Assurance of cost recovery for cost-effective DSM investments is critical to convince utility managers (who are used to investing in tangible supply side resources) to engage in less tangible energy efficiency projects. DSM expenses, if prudently incurred, are automatically passed on to all ratepayers through the fuel adjustment charge.

Implementation strategies should explicitly consider the cultural and sociological context within which the programs are being offered. In a society, where agreements (to improve the efficiency of product at the manufacturing level) are more easily reached by negotiations, price driven incentives (to consumers or manufacturers) may not be necessary. Reaching a voluntary agreement often requires extensive consultations with key stakeholders including equipment manufacturers and distributors, the financia community, engineering experts, appliance testing agencies, various trade associations a well as customers. Through dialogue with all stakeholders, the energy saving opportunitie and program designs that would maximize the penetration of high efficiency technologie could be identified.

CHAPTER 6

DSM OPTIONS FOR DELHI - A CASE STUDY

INTRODUCTION

The electrical energy demand[1] of Delhi system is increasing at a rapid rate and the average growth for the last 10 years is around 7.5%. Delhi's peak demand has been forecasted to increase to 3823 MW and the energy requirement to 22771 MkWh in the year 2004-5.

As is seen from the category-wise consumption pattern[2] for Delhi on the next page, domestic sector is the largest consumer of power in Delhi accounting for nearly 45% of the total energy consumed. Commercial(28%), Industrial (L&MV) sector (12.5%) and Industrial (HV) sector (6.7%) are the other major users of electricity. All these types of consumers account for approx. 92% of the total energy consumed.

During the extreme summer and the winter months, peaking shortage is experienced because the power available falls short of the demand and frequent power cuts/restrictions have to be resorted to so as to reduce the peak demand on the system. Having studied the various DSM options, it is felt that proper application of these options to the power system of Delhi can bring about a better balance between the power available and the power demand. The methods for DSM as discussed in the previous chapters include load management, improvement in end-use efficiency, pricing options and incentives to the customers so as to encourage them to use electrical energy judiciously.

The typical load curves of Delhi for summer and winter have been analyzed along with representative load curves of domestic, commercial and industrial sectors, which are the dominant consumer sectors. Each of these sectors have been analyzed separately to determine their individual contribution to the system load. Accordingly, strategies have been evolved to effect demand management.

Having achieved flattening of the load curve to the extent possible, further savings in energy is possible by use of energy efficient technologies. Some of the options have been applied to the system of Delhi and the expected savings in the energy have been calculated.

The pricing of electricity is another tool which creates incentives for implementation of energy efficient measures. The present tariff structure as applicable to the various categories of consumers has been studied and tariff options which would promote objectives of DSM i.e. shifting of load from peak to off-peak hours and curtailment of demand have been suggested.

Reasons for a high value of T&D losses (around 46.86%) in the power system network of Delhi have been identified and measures suggested for reducing the same.

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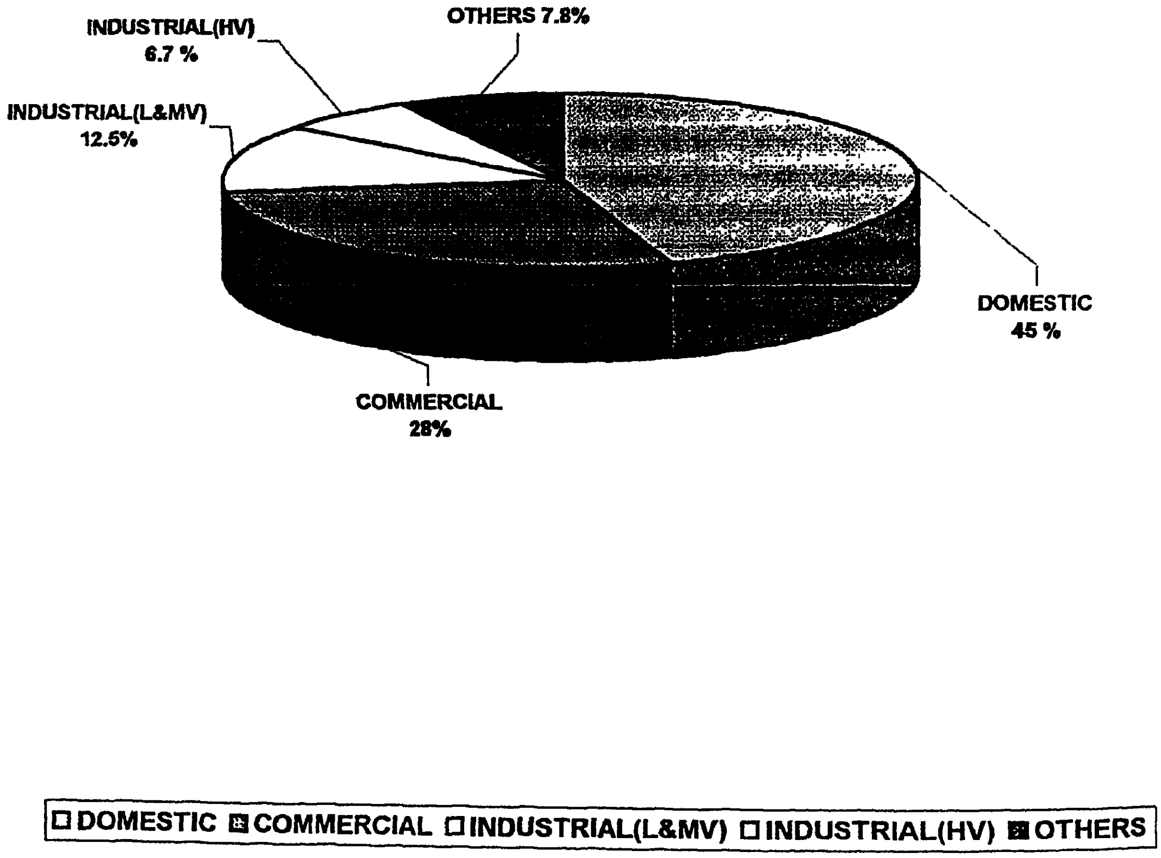
[1] DMLF Division, CEA

[2] Data source - DVB

CATEGORYWISE CONSUMPTION PATTERN - DELHI



ELECTRICAL DISTRIBUTION SYSTEM IN DELHI[3]

The electrical energy supply in Delhi is under the control of Delhi Vidyut Board (DVB). The total area of Delhi is 1483 sq. kms. New Delhi Municipal Committee (area 42.74 sq. kms.) and MES (for feeding cantonement area of 42.97 sq. kms.) are the two licencees to supply power to their respective areas.

The current maximum demand of Delhi is 2832 MW. DVB's own generating plants (IP, RPH and Gas Turbine plants) supply 664.5 MW. The remaining is received from the Northern Region Power Grid of which DVB is a constituent partner. Power is drawn from the grid at 400 kV and 220 kV level for which DVB has established a number of 400 kV and 220 kV sub-stations along with transmission lines. Since DVB's own generation is less than 25% of the total demand, Delhi is heavily dependent on the Northern Region Grid for meeting its power requirements. Whenever there is any problem in the Northern Grid (due to outage of generating units feeding this Grid or a fault in the transmission system connecting these generating units to the sub-stations) the power supply to Delhi is adversely affected.

LOAD MANAGEMENT[4]

Load management involves assessment of the total unrestricted demand of Delhi and the total load being met by the present generation available. For this, data regarding the hourly load of Delhi system for peak demand day in each summer month from April '99 to August '99 and for peak demand day in each winter month from Nov. '98 to Feb. '99 was collected from DVB and it was analyzed to obtain system level hourly load shapes of peak demand day of summer and winter each. The hourly unrestricted demand for summer and winter was arrived at by adding the hourly load shedding to the demand met. The hourly load shapes for domestic (R.K. Puram and Vasant Kunj), commercial (Bhikaji Cama Place and Nehru Place) and industrial (Okhla Phase-I and Phase-II) areas have also been developed for the summer and the winter season after analyzing the data for the above mentioned summer and winter months. These sector load shapes have been determined by collecting data from the concerned grid stations/feeders as they are largely dedicated to domestic, commercial and industrial load respectively with minor mixed load of other consumer category. These load curves are broadly representative of consumption pattern in these sectors during the months of summer and winter. Even though this is an approximation, it is assumed that sample feeders are truly representative of that category of consumers.

System load shape analysis

Figure 1 gives the hourly demand shapes of Delhi for the peak demand day in summer '98 and summer'99 while Figure 2 gives the same for winter '97 and winter '98. It is noted that the demand pattern follows the same trend every year with minor variations. However, the value of peak demand increases in the subsequent year. It was noted that during the summer season, the peaks were amongst the highest in July '99 with the peak demand occuring on 26.7.99. Therefore, the demand curve for this day is truly representative of the peak demand of the summer season. In winter season, the peaks were amongst the maximum in January '99 with the peak demand occuring on 22.1.99. Therefore, the demand curve for this day is truly representative of the peak demand of the winter season.

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[3] Data Source - DVB

[4] Data collected from DVB S/Ss

The analysis of the curve for summer season shows some gap between the restricted (solid curve) and unrestricted demand (dotted curve) and the gap is considerable from 1600 hours to 2300 hours. This means that load shedding was necessary. It is noted that the extent of load shedding during summer 1999 is marginally less as compared to that in summer 1998. In summer 1999, the load shedding was maximum (154 MW) at the time of evening peak i.e. at 2200 hours. The load factor of the load met is .88 while that of unrestricted demand is .84 while the energy shortfall in the day is .7 million units. This shows that there is very little scope for load management. The load attained at 2200 hours is due to lifting of restrictions on the use of air conditioners and other sectors where restrictions are imposed.

The analysis of the curve for the winter season shows that the demand starts increasing at around 0600 hours, rises to a peak of 2500 MW at 0800 hours, again decreases to a low of 1975 MW at 1600 hours and then rises to an evening peak of 2450 MW at 1900 hours and then again decreases during the night. The load shedding is maximum between 0700 hours and 1200 hours in the forenoon and between 1800 hours and 2200 hours in the evening. The maximum load shedding is 299 MW at 1900 hours. The load factor of the restricted and unrestricted demand is .78 while the energy shortfall during the day due to load shedding is 1.5 MU which shows that there is some scope for load management.

Sector load shape analysis

The major power consuming sectors(domestic, commercial and industrial) have been analyzed separately to determine their individual contribution to the system load shape. Since the contribution of other sectors like agriculture, public lighting. traction etc. is very less , they have not been analyzed for load management.

Analysis for the summer season

Domestic Sector

The hourly load data of 33/11 kV R.K.Puram and 66/11 kV Vasant Kunj 'C'Block grid S/Ss which are feeding mainly domestic areas have been plotted to obtain representative load profiles of domestic sector. The same have been given in figs. 3(a) and 3(b) respectively. An analysis of the demand curve for R.K.Puram S/S shows that the demand is nearly constant throughout the day. The zero demand from 1500 hrs. to 1600 hrs. is not due to decrease in demand but due to incoming supply failure. Because of the nearly constant demand, the load factor is quite high i.e. .82 thereby indicating very little scope for load management. The energy shortfall during the day due to incoming supply failure is .015 MU. An analysis of the curve for Vasant Kunj S/S shows that the demand on the system is high at midnight and then starts decreasing, reaches the lowest value at around 0800 hrs., remains almost constant throughout the day and then again starts increasing at

1800 hrs. reaching to the peak value of 6.75 MW at 2400 hrs. The load factor of the curve is .66 and a possibility of application of load management techniques exists.

If a comparison is made between the load profiles of the domestic sector and the system load profile, it is seen that the system off-peak during early morning is due to the fact that the domestic load also reduces considerably during this time and the evening peak of the system is due the domestic load also peaking at this time. The domestic load is mainly due to the use of coolers, air conditioners, bulbs, tubes, fans, refrigerators etc. Since it is not possible to shift such types of loads to some other time, the possibility of shifting peak domestic load to off-peak hours is limited.

Commercial Sector

The hourly load data of the peak demand day of 33/11 kV Bhikaji Cama Place and 33/11 kV Nehru Place S/Ss which are feeding mainly commercial areas have been plotted to obtain representative load profiles of the commercial sector. The same are given in figs. 4(a) and 4(b) respectively. An analysis of the curve for Bhikaji Cama Place S/S shows a declining trend of the demand from midnight to early morning hours and then it starts increasing, reaching a peak value of 26 MW at 1700 hrs. and then again starts decreasing. The zero demand from 1500 hrs. to 1600 hrs. is due to incoming supply failure. The load factor of the curve is .64 showing scope for load management. The energy shortfall during the day due to incoming supply failure is .024MU. The curve for Nehru Place S/S also shows a declining trend of the demand from midnight till early morning hours, after which the demand starts increasing (with a dip at 1100 hrs.) reaching a peak value of 47 MW at 1500 hrs. and then again starts decreasing and then again increases and the demand at 2400 hrs. is about the same as at 00 hrs. The load factor of the demand on Nehru Place S/S is .76 while the energy shortfall during the day is .015 MU. The curve also shows that some load shedding was necessary from 1100 hrs. to 1300 hrs. and from 1600 hrs. to 1800 hrs..

An analysis of the system load profile and the load profile for commercial sector shows that the off-peak hours during night/early morning are the same in both the cases. The commercial load remains high almost throughout the day from 1000 hours to 1730 hours. The increase in commercial load from 1000 hrs. coincides with the increase in system load around this time. The commercial load is mainly due to market places and business cum office complexes. Therefore, market places with maximum loads should remain open on Sundays when the loads of business cum office complexes is minimum. Restrictions should be imposed on the use of air conditioners during peak hours and use of energy efficient devices should be encouraged.

Industrial Sector

The hourly load data of Okhla Phase-I and Phase-II grid S/Ss which are feeding predominantly industrial areas have been plotted to obtain a representative load profiles of industrial sector. The same are given in figs. 5(a) and 5(b). The curve for Okhla Phase-I shows a low value of demand during early morning hours and the demand starts increasing at 0900 hrs. when the industries start operating. The zero demand from 1100 hrs. to 1200 hrs. is due to incoming supply failure. The demand increases and reaches a peak value of 22.5 Mw at 1400 hrs. The unrestricted demand remains at 22.5 MW till 2400 hrs. but the demand is restricted to a low value by load shedding. The load factor of the demand on this S/S is .595 and the energy shortfall during the day due to load shedding and incoming supply failure is .124 MU showing scope for load management. The curve for Okhla Phase-II S/S also shows a low value of demand during early morning hours and the demand starts increasing at 0900 hrs. reaching a peak value of 21.8 MW at 1200 hrs. after which the demand remains high till 1800 hrs. The restricted demand shows a declining trend after 1800 hrs. while the unrestricted demand has some peaks at 1900 hrs. and at 2100 hrs. which means load shedding was necessary at these times. The factor of the demand is .52 and the energy shortfall during the day due to load shedding is .006 MU which indicates that the possibility of application of load management techniques exists.

An analysis of the system load profile and the load profile of industrial sector shows that the off-peak hours during early morning are the same in both the cases and the increase in industrial load at 1000 hrs. coincides with an increase in system load around this time. The analysis shows that most of the industries are in operation from 0900 hrs. to 1700 hrs. with some industries also operating during the night. It is suggested that incentives should be offered to industries to encourage operation during early morning hours. TOD metering should be introduced for HT consumers to start with. Energy efficient practices should also be adopted by the industries.

Analysis for the winter season

Domestic Sector

Figs. 6(a) and 6(b) give the load profiles of 33/11kV R.K. Puram S/S and 66/11kV Vasant Kunj 'C' Block S/S respectively for the winter season. The load profiles for the two S/Ss are almost similar. The load starts increasing at 0700 hrs. when the load of geysers in addition to the lighting and heating load comes on the system. The load profile has a morning peak between 0800 hrs. and 1000 hrs. after which the load starts decreasing and the curve has a dip at around 1500 hrs. The load again starts increasing at 1800 hrs. when the lighting and the heating load comes on the system. There is an evening peak at around 2000 hrs. but this peak is low as compared to the morning peak and after reaching the peak value, the load again starts decreasing. The load factor for the demand on R.K.Puram S/S is .67 showing scope for load management while the load factor in case of Vasant Kunj S/S is .83.

If a comparison is made between the load profile of the domestic sector and the system load profile, it is seen that the profiles are very similar with morning and evening peaks occuring at around the same time. This shows that the domestic load has a very predominant effect on the system load profile. The load of the domestic sector during the winter season is due to the use of geysers, heaters and lighting in addition to fridge, TV etc.. Most of these loads cannot be shifted to some other time except the geyser load which can be shifted to early morning hours if TOD metering is implemented. Use of energy efficient devices would also help in reducing the demand on the system.

Commercial Sector

Figs. 7(a) and 7(b) give the load profiles of 33/11kV Bhikaji Cama Place and 33/11kV Nehru Place grid S/Ss respectively for the winter season. Both the curves show a similar trend. The demand is low during early morning hours, the demand increases at 0900 hrs. with the demand peaking at around 1200 hrs.. After this the demand decreases and it again rises to an evening peak at around 1900 hours and after the evening peak, the demand again shows a declining trend. The load factor of the demand on Bhikaji Cama Place S/S is .62 while that on Nehru Place S/S is .65 showing scope for load management at these two S/Ss.

An analysis of the system load profile and the load profile for commercial sector shows that the off-peak hours are the same in both the cases. Also, the demand of the commercial sector remains high almost throughout the day and the commercial load. is quite high at the time of morning and evening peaks of the system load profile. Thus it can be said that the impact of commercial load on the total system load is quite substantial. It is suggested that the business cum office complexes should close by 1730 hrs. and the market places should close by 1900 hrs. to avoid contribution to the evening peak. Use of energy efficient devices would also help in reducing the demand on the system.

Industrial Sector

Figs. 8(a) and 8(b) give the load profile of Okhla Phase-I and Phase-II grid S/Ss respectively for the winter season. An analysis of the curves shows that the load is low during early morning hours and starts increasing at around 0900 hrs.. The load remains high almost throughout the day and starts decreasing at around 1700 hrs.. The unrestricted demand in case of Okhla Phase-II S/S remains high till about 2300 hrs. in the night which necessitated load shedding from 1800 hrs. to 2300 hrs. The load factor of the demand on Phase-I S/S is .79 while that on Phase-II S/S is .47 and the energy shortfall during the day due to load shedding on this S/S is about .81 MU showing scope for load management.

An analysis of the system load profile and the load profile of industrial sector shows that the off-peak hours are the same in both the cases and the impact of industrial load on the evening peak of the system load profile is substantial. Therefore, operation of industries during off peak hours and use of energy efficient practices in this sector should be encouraged.

The following measures are recommended to effect load management:

Domestic Sector

1. Use of energy efficient appliances should be encouraged.
2. Restriction on the use of air conditioners during peak hours.

Commercial Sector

1. Market places with maximum load should remain open on Sundays when the load of business cum office complexes is minimum.
2. The business cum office complexes should close by 1730 hrs. to avoid contribution to the evening peak.
3. The market places should close by 1900 hours to avoid contribution to the evening peak.
4. Neon signs and decorative lighting should be banned during peak hours.

5. Use of energy efficient appliances should be encouraged.

Industrial Sector

1. Encourage operation of industries during off-peak hours.
2. TOD metering should be introduced for HT consumers with low tariff during off-peak hours.
3. Use of energy efficient practices in industries should be encouraged.

END-USE EFFICIENCY

An analysis of the load curves shows that the shifting of loads from peak to off-peak hours can be achieved only upto a limited extent beyond which the flattening of load curve is not practicable. Further savings in energy to bridge the gap between demand and supply is possible through an enhancement in the end-use efficiency. Some sample calculations showing the energy saving potential in the domestic sector and the agricultural sector (though the agricultural demand on the system of Delhi is very less) have been given below:

Energy Savings in Domestic Sector

To have an idea of the energy saving potential, a survey of domestic energy usage pattern in Vasant Kunj was carried out. The details are as under:

The total number of flats in this area is about 10,000 out of which about 8,000 are occupied. Out of these 8,000 flats, nearly 3,000 flats have air conditioners. Moreover, about 20% of these flats have more than one air conditioner. Therefore, the total number of air conditioners in this area can be estimated to be around 3700. All the flats have at least one room cooler in each flat in addition to fans in all the rooms. The average usage pattern was found to be as under:

1. One air conditioner of 2kW for 7 hours a day for 140 days in a year.
2. One cooler of 200W for 8 hours a day for 120 days in a year.
3. Two fans of 80W each used for 15 hours each day for 180 days in a year.
4. Three tube-lights of 40W with 14W magnetic ballast used for 6 hours each day throughout the year.
5. One refrigerator of 165 litre used all the year round.
6. One geyser of 1.5 kW used for one hour per day for 150 days in a year.

Based on the above data, the energy usage as at present and the possible energy savings through the use of energy saving appliances are as under:

Air conditioners(a.c.)
Present energy consumed per year = $3700 \times 7 \times 140 \times 2 = 7.25 \times 10^6$ kWh
If air conditioners with higher EERs (around 7.0) are used saving potential of at least 10% can be achieved which is = $.725 \times 10^6$ kWh/year

Refrigerators

The load of refrigerator is an intermittent kind of load. Assuming that a refrigerator runs for approx. hours in an year ,a typical 165 litre Indian refrigerator would consume approx. 540 kWh/year while a 200 litre Korean model would consume approx. 240 kWh/year.

Present energy consumed per year = 8000x540 = 4.32×10^6 kWh

If Korean model is used, energy consumed per year = 8000x240 = 1.92×10^6 kWh

Savings = 2.4×10^6 kWh/year

Fans

Present energy consumption = $8000\times2\times80\times15\times180/10^3 = 3.46\times10^6$

If fans with higher motor efficiency and electronic speed regulators are used, at least 10% savings are possible.

Savings = $.346\times10^6$ kWh/year

Tube-lights

Present energy consumption = $8000\times3\times(40+14)\times6\times365/10^3 = 2.84\times10^6$ kWh/year

If electronic ballasts and 36W tubes are used, energy consumption=2.1×10^6 kWh/year

Savings = $.74\times10^6$ kWh/year

Coolers

Present energy consumption = $8000\times200\times8\times150/10^3 = 1.92\times10^6$ kWh/year

If coolers with higher efficiency fans and pumps are used, saving potential = 20% = $.384\times10^6$ kWh/year

Geysers

Present energy consumption = $8000\times1.5\times1\times150 = 1.8\times10^6$ kWh/year

If geysers with better quality insulation are used, savings possible = 10%= $.18\times10^6$ kWh/year

Total energy savings possible through the use of energy efficient devices = 4.775×10^6 kWh/year

The above calculations show that if energy efficient devices are used, annual energy savings of 4.775×10^6 kWh/year are possible in a small domestic area like Vasant Kunj. Evidently, the savings for the entire system of Delhi would be enormous.

Energy savings in Agricultural sector

Total number of agricultural pumpsets in Delhi = 25284

Average capacity per pumpset = 3.5 kW

Total number of hours per year for which pumpsets are used = 650

Overall efficiency of pump and motor = 40%

Present agricultural consumption = $25284\times3.5\times650/.4 = 143.8\times10^6$ kWh/year

If higher efficiency pumpsets are used and rectification of the existing pumpsets to the extent possible are carried out, at least 20 % savings are possible which are = 28.76×10^6 kWh/year

Even though the demand of the agriculture sector in Delhi is very less, still it can be seen that some energy savings are possible because most of the pumpsets purchased by farmers are non ISI mark which have efficiency levels quite low as compared to ISI marked pumpsets.

Potential for energy savings in Vasant Kunj, in the entire domestic sector of Delhi and in the agricultural sector of Delhi have been tabulated below:

POTENTIAL FOR ENERGY SAVINGS THROUGH AN INCREASE IN END-USE EFFICIENCY			
Equipment/device	Present Annual Energy Consumption MkWh/year	Annual Energy Consumption by Efficient Devices MkWh/year	Annual Savings Possible MkWh/year
(i) Domestic sector			
Air Conditioners	7.25	6.525	.725
Refrigerators	4.32	1.92	2.4
Fans	3.46	3.114	.346
Tube-lights	2.84	2.1	.74
Room Coolers	1.92	1.536	.384
Geysers	1.8	1.62	.18
Total	21.59	16.815	4.775
Savings in energy in Vasant Kunj	22.107%		
Present Annual Energy Consumption in Delhi (Domestic Sector)[5]	3404.405 MkWh/year		
Taking a conservative estimate, potential for energy savings in the domestic sector of Delhi can be assumed to be about 18% which is	612.79 MkWh/year		
(ii) Agriculture Sector			
Pumpsets	143.8	115.04	28.76

The above calculations quite clearly bring out the fact that the use of energy efficient devices can lead to huge amount of energy savings. Therefore, such devices should be used to the maximum extent possible by various categories of consumers. In addition to the use of such devices, it has been noted that particularly in offices and educational institutions, lights and fans are switched on as soon as they are opened and they remain on throughout the day. Even coolers, room heaters and air conditioners are not switched off while leaving the room. It is felt that people should be made more conscious of the fact that even small acts on their part can lead to huge amount of energy savings. For this, posters with the following text written on them should be displayed clearly at all the prominent places in offices/educational institutions:

ENERGY CONSERVED IS ENERGY GENERATED

Ensure that Lights / Fans / A.C.s / Coolers etc. are switched off when not required.

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[5] Data Source - DVB

CURRENT TARIFF STRUCTURE OF DVB[6]

Domestic, commercial, industrial and agricultural sectors are the major users of electricity in Delhi. The present tariff structure has been designed in such a manner that the electrical energy supply to the agriculture and domestic sectors is heavily subsidized at the expense of industrial and commercial sectors. The tariffs for various categories of consumers are as below :

Category	Rates (Rs. Per unit plus demand charges Rs./kVA/Month)	In excess of Normative consumption (%)	Normative Consumption limit (kW/Month)
1. a) Domestic lighting and fan			
1-100 units	1.00		
101-200 units	1.75		
201-400 units	2.50		
Above 400 units	3.00		
b) Domestic Power Plus demand charges of Rs. 60/kW	3.00		
2. a) Non-Domestic (LT)			
i) Single Phase	3.00	30	200
ii) Three Phase	4.00	30	200
b) Non-Domestic (HT)			
i) Plus demand charges Rs. 150/kVA/month on 11 kV	3.50		
ii) Plus demand charges Rs. 200/kVA/month on 400V	4.50		
3. a) Small Industrial Power (SIP)			
i) Non-continuous industries	3.00	30	300
ii) Continuous industries	3.00	30	300
iii) Industries without license	4.00	30	300/400
4. Agriculture			
a) For tube-wells, thrashers, crushers etc. upto a load of 10 kW	0.50		
b) For any other use including farm house etc.	5.00		

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[6] Data Source - DVB

The following changes are proposed in the current tariff structure of DVB so as to encourage consumers towards more efficient use of energy:

1. The above tariff structure shows that DVB has fixed certain minimum demand charges for every consumer. These demand charges are based on the connected load and are, in general, pretty high. DVB justifies these demand charges by the reasoning that a consumer who does not use electricity during a certain period has zero electricity bill whereas he has caused a definite expenditure due to the readiness of the utility to serve him. However, this argument is valid only if electricity is abundantly available. The charging of minimum demand charges under the present conditions of shortage of power and an unreliable power supply is unjustified. Also, because of these minimum demand charges, consumers tend to use a certain minimum amount of energy every month which leads to wastage of energy and further loads the already overloaded system. In view of this, it is felt that fixing of minimum demand charges is totally unjustified. It is worth mentioning that in advanced countries where there is no shortage of electricity and the voltage conditions are excellent, there are no minimum demand charges for any category of consumers.
2. Inverted tariff structure which is presently applicable only for the domestic consumers, should also be introduced for commercial and industrial consumers.
3. Use of air conditioners in domestic and commercial sector should be restricted through the application of prohibitive tariff for such users. Registration of air conditioners should be made compulsory.
4. The concept of TOD pricing should be made compulsory for HT industrial users to start with.
5. The present tariff for agricultural consumers is so low that it is much below the cost of even generation. This is totally unscientific and irrational. A rational tariff structure for this sector should be introduced.
6. To encourage consumers to participate in DSM programmes, incentives are necessary. If the electricity consumption in an year for any consumer is less than the previous year's consumption, a rebate equal to the percentage decrease in the energy consumption should be given in the current year's bill.

   On the other hand, if the electricity consumption in any year for any consumer is more than the previous year's consumption, a penalty equal to the percentage increase in the energy consumption should be levied in the current year's bill. This would compel the consumers to use electricity judiciously.

T&D LOSSES IN DVB SYSTEM

Delhi electric supply system has a peculiar characteristic having T&D losses of around 46.86% (amongst the highest in the country). The distribution system of Delhi is very compact as compared to that in other states and load density is about 1.9 MW/sq. km. of the area. For such a system, the losses should not exceed around 10-12%. A high value of T&D losses further increases the gap between demand and supply. In addition if T&D losses in the power system network are high, the revenue collected by the utility would be less and the utility would not have sufficient resources to fund the DSM programmes. Such a high value of T&D losses in Delhi can be attributed to:

1. Old and outdated distribution system.
2. Improperly planned and ad-hoc expansion of distribution system.

3. Extremely long length of LT lines.
4. Inadequate reactive compensation.
5. Improper load management resulting in overloading of the system.
6. Large scale theft and pilferage of electrical energy.

The following steps are recommended to reduce T&D losses:

1. A review of location of distribution transformers keeping in view the increased loads of consumers. An increase in HT/LT ratio of distribution lines.
2. Renovation of LT distribution system using proper size conductors keeping in view the existing as well as future increase in loads.
3. Extensive use of shunt capacitors for improvement of power factor.
4. Application of proper load management techniques.
5. Strict vigilance and surprise raids to detect theft of energy and heavy penalties for the theft cases detected.
6. Regular inspection of the feeders and distributors to detect direct tapping.
7. Energy audit extending to all categories of consumers wherever feasible.
8. Installation of tamper proof energy meters.
9. Incentives and rewards to employees detecting theft and pilferage.
10. Strict disciplinary action against employees in whose areas theft and pilferage is detected.

If the measures as recommended above are implemented by DVB and the consumers of Delhi, to the extent possible, they can go a long way in mitigating the power shortage situation as is presently being faced in the state of Delhi and would also lead to an improvement in the power quality and reliability.

CONCLUSIONS

In the current scenario of the peak demand exceeding the supply and the building up of new power plants and the associated T&D systems becoming more and more costly and also environmentally unfriendly, it is felt Demand Side Management is an approach which can help the utilities in reducing energy consumption and co-incident maximum demand on their systems, and to achieve this without any adverse economic, social and environmental impacts, thereby leading to sustainable development. This project report gives broad guidelines of the DSM measures which can be adopted by the utilities to achieve the above mentioned aim. An attempt has been made to apply some of the DSM techniques to the electrical energy system of Delhi.

Proper implementation of DSM activities can decrease the use of primary energy resources as well as decrease the harmful effects of energy conversion on the environment. This approach starts with peak load reduction by shifting the demand away from the peak periods and at the same time emphasizes on an enhancement in end-use efficiency and energy conservation. The effect of demand reduction is to cut down the emissions of CO_2, SO_x and NO_x associated with the fossil fuels saved. Load shaping also has some environmental impacts. With load shaping, older and less efficient generating stations would run for a smaller number of hours, in favour of more efficient power plants thereby leading to reduced environmental impacts. The burden of pollutant removal and, eventually the taxation of pollutants, are making supply side options more expensive and hence DSM options increasingly attractive. Also, energy efficient technologies seek to provide the same output levels as the conventional technologies but at a lower rate of energy consumption. Though energy efficient technologies cost more than the conventional technologies, the increased cost is more than compensated through the energy savings achieved over the life time of the equipment. In addition, the tariff structure adopted by the utilities should be such that consumers are encouraged towards more efficient use of energy.

DSM programmes can be successful if they are accepted willingly by the consumers. Financial incentives are an essential requirement for successful acceptance of the programmes by the consumers. The utilities must pass on some of its savings (achieved through the implementation of DSM programmes) to the customers. The tariff structure adopted by the utilities should have provision for incentive for off-peak energy use and penalty for high loads demanded during peak hours. Offering financial incentives to the customers to go in for energy efficiency and energy conservation measures is an important part of DSM. Govt. and non-Govt. organizations can promote energy efficient technologies through incentives, publicity campaigns and other such measures.

DSM implementation measures should be related to the customer needs and to finding the optimum solution in terms of meeting environmental objectives at minimum overall cost. Also, DSM programmes should be dynamic in nature which means that their structure and thrust should change with the changing needs of the utility and its customers.

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HOURLY LOAD PATTERN OF DELHI SYSTEM FOR PEAK SUMMER DAY

FIG.1(a) SUMMER '99 (PEAK DAY-26.7.99)

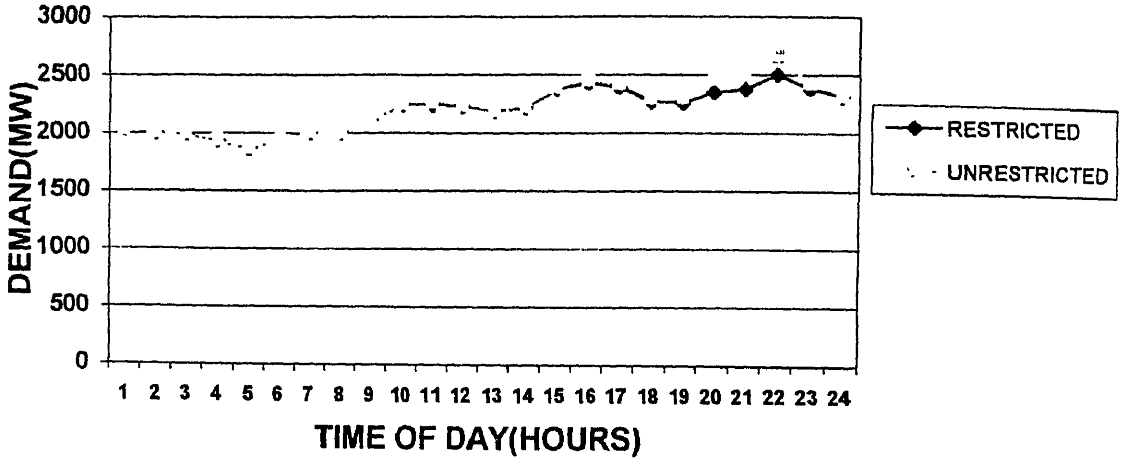
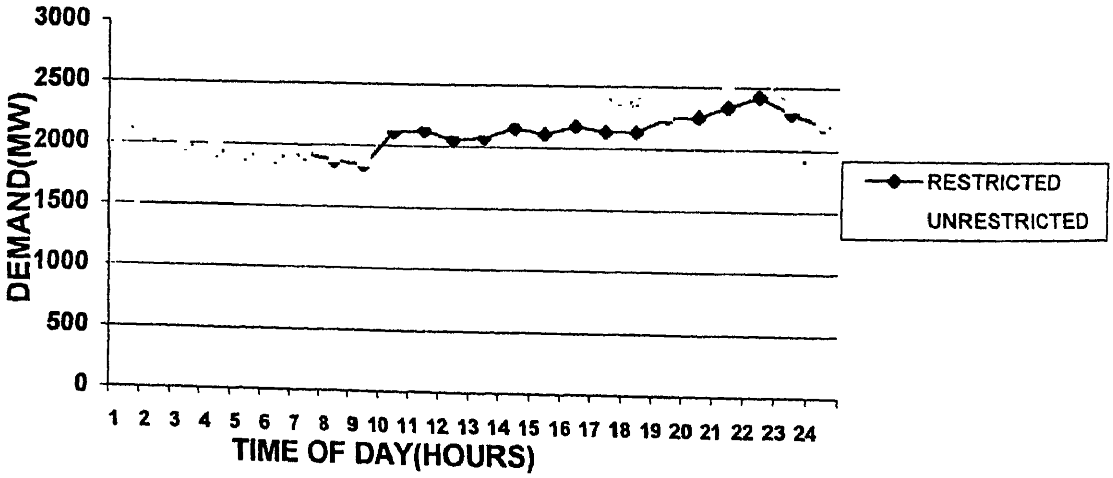


FIG.1(b) SUMMER '98 (PEAK DAY-4.8.98)



HOURLY LOAD PATTERN OF DELHI SYSTEM FOR PEAK WINTER DAY

FIG. 2(a) WINTER '98 (PEAK DAY-20.1.99)

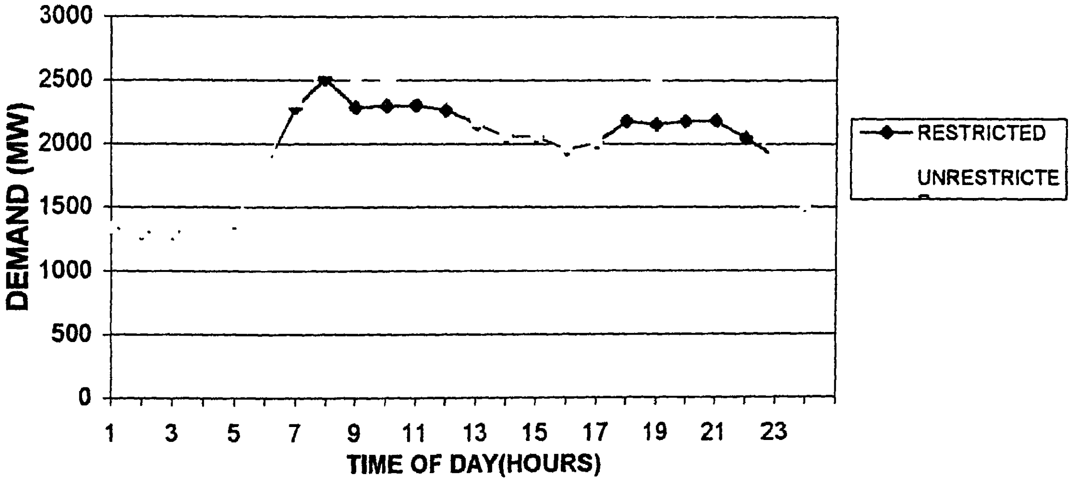
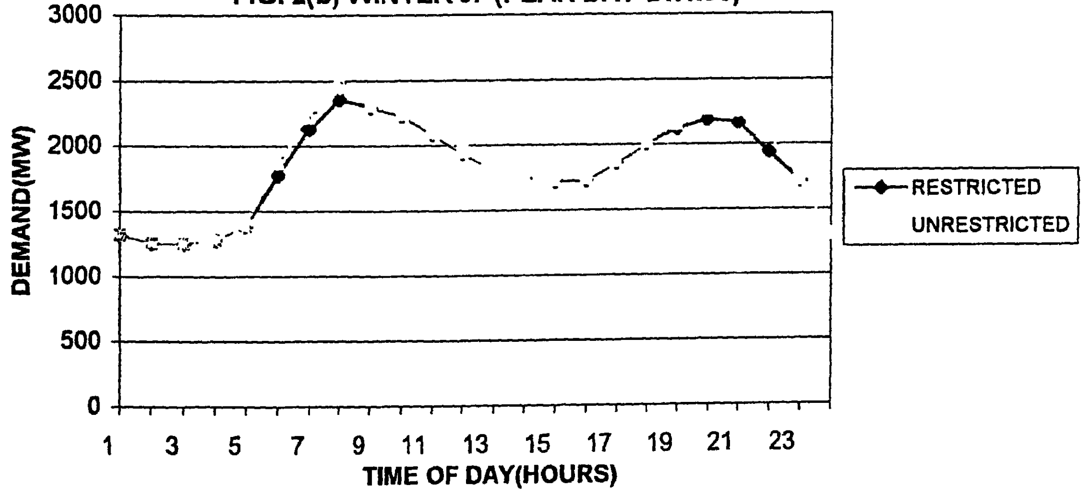


FIG. 2(b) WINTER'97 (PEAK DAY-21.1.98)



HOURLY LOAD PATTERN OF TWO Nos DOMESTIC FEEDERS IN SUMMER '99

FIG.3(a) R.K.PURAM 33/11 kV GRID S/S (PEAK DAY-14.7.99)

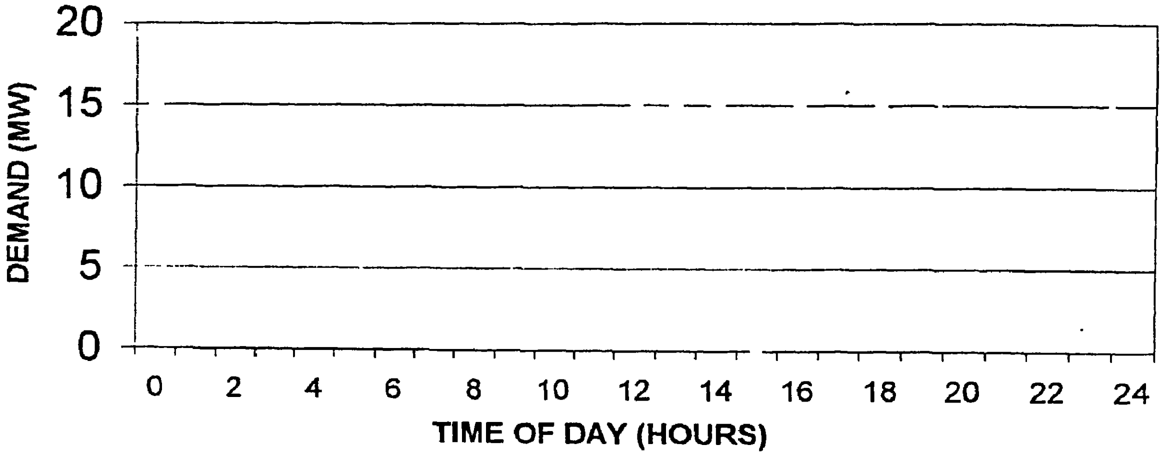
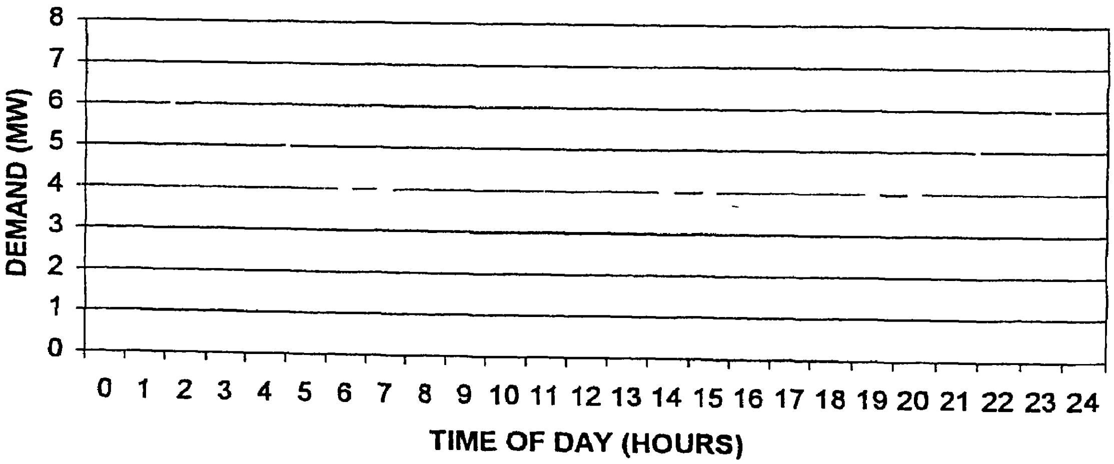


FIG. 3(b) VASANT KUNJ 'C' BLOCK 66/11 kV GRID S/S(PEAK DAY-5.7.99)



HOURLY LOAD PATTERN OF TWO Nos. COMMERCIAL FEEDERS IN SUMMER'99

FIG. 4(a) BHIKAJI CAMA PLACE 33/11 kV GRID S/S
(PEAK DAY-16.7.99)

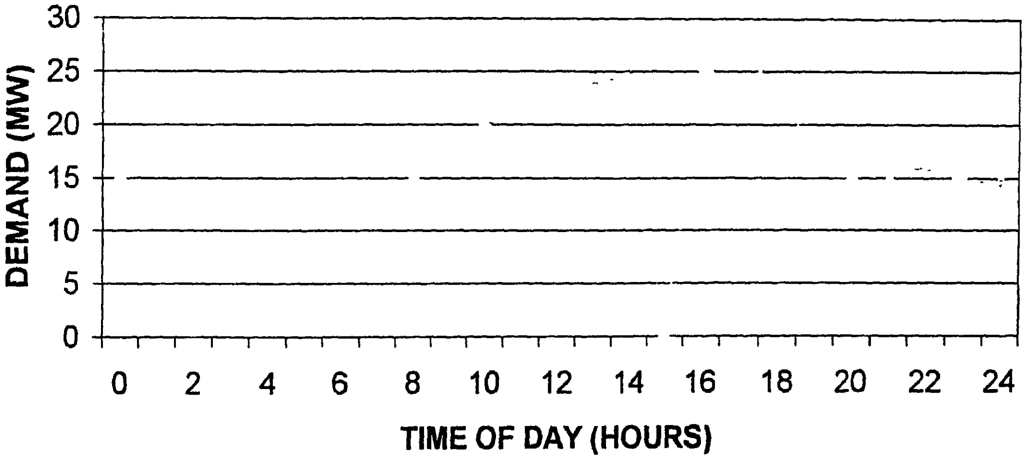
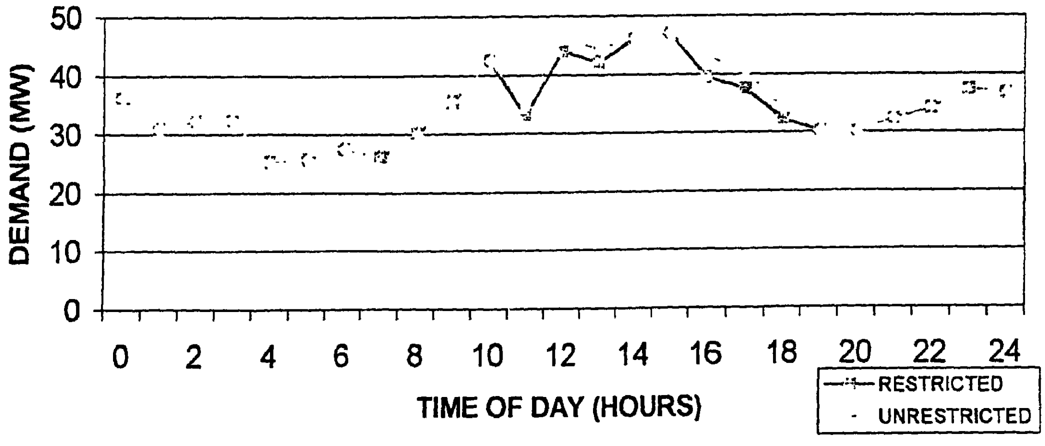
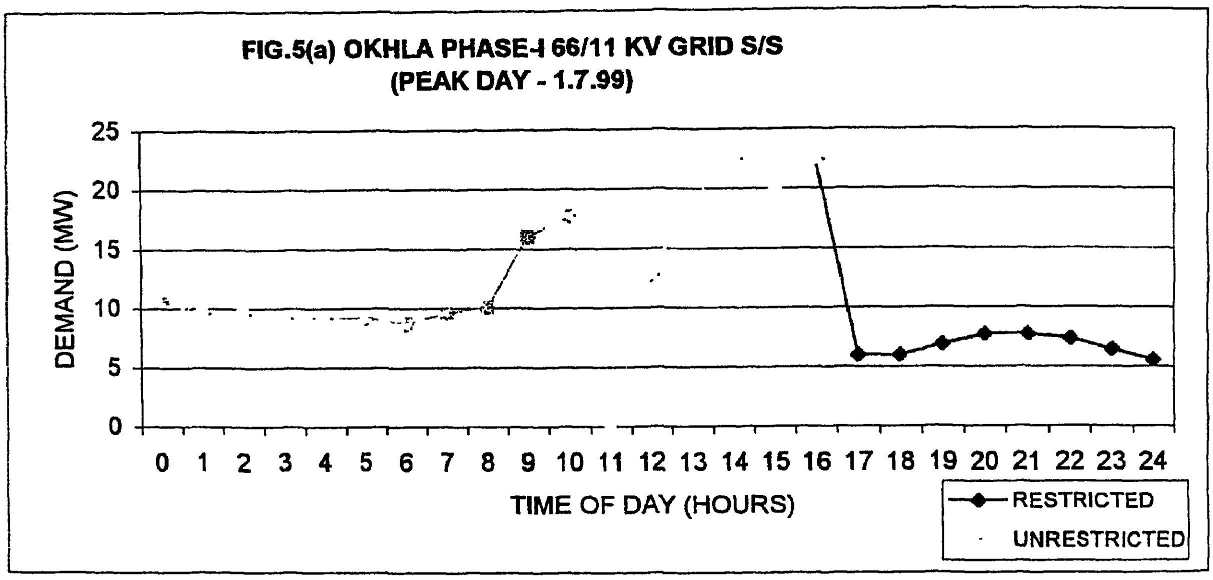
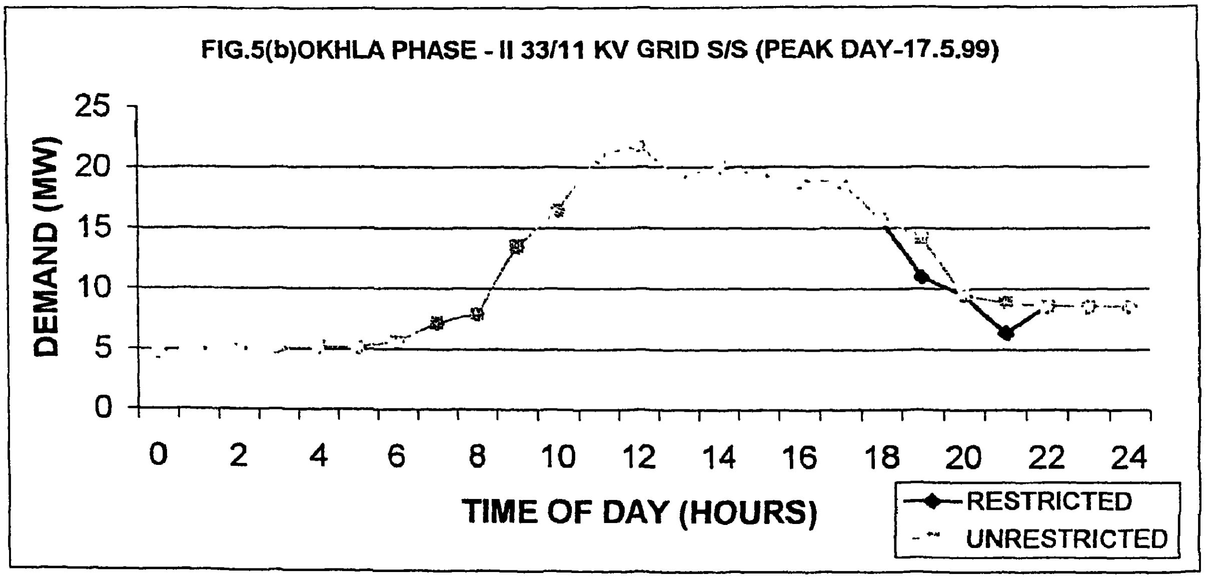


FIG. 4(b) NEHRU PLACE 33/11 kV GRID S/S (PEAK DAY-14.6.99)



HOURLY LOAD PATTERN OF TWO NOS. INDUSTRIAL FEEDERS IN SUMMER '99





HOURLY LOAD PATTERN OF TWO Nos. DOMESTIC FEEDERS IN WINTER '98

FIG.6(a)R.K.PURAM 33/11 kV GRID S/S (PEAK DAY-14.1.99)

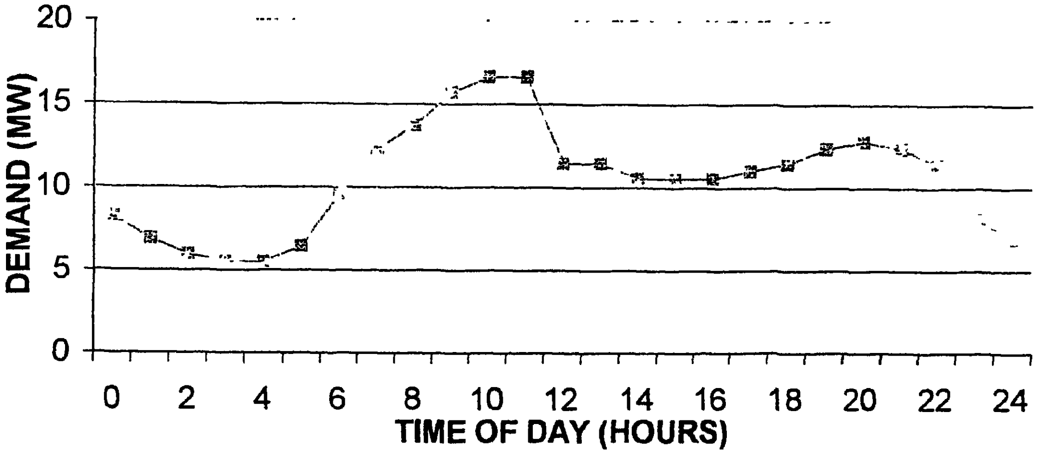
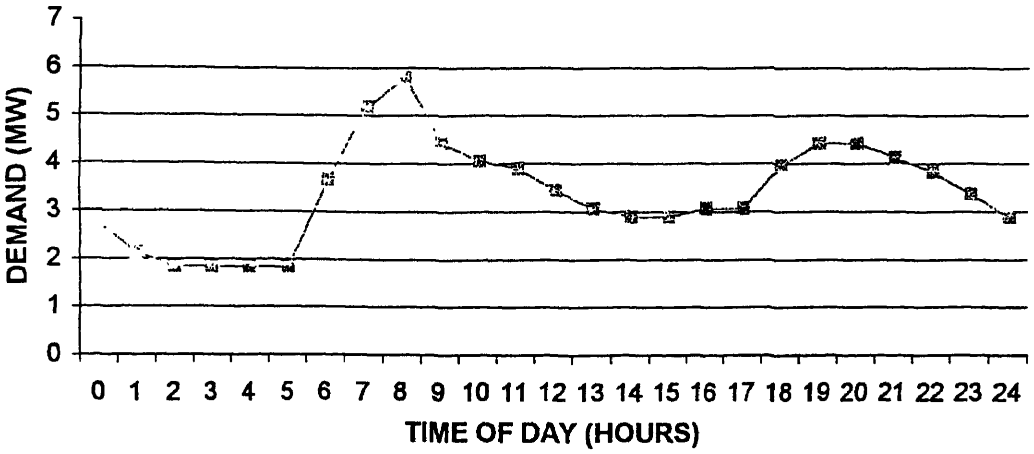


FIG.6(b)VASANT KUNJ 66/11 kV GRID S/S (PEAK DAY-12.1.99)



HOURLY LOAD PATTERN OF TWO Nos. COMMERCIAL FEEDERS IN WINTER'98

FIG.7(a) BHIKAJI CAMA PLACE 33/11 kV GRID S/S (PEAK DAY-30.12.98)

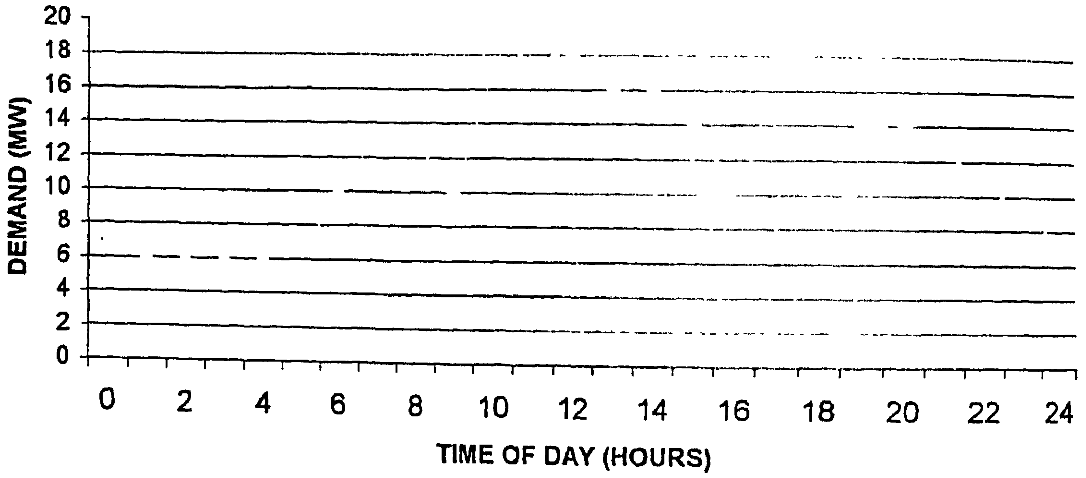
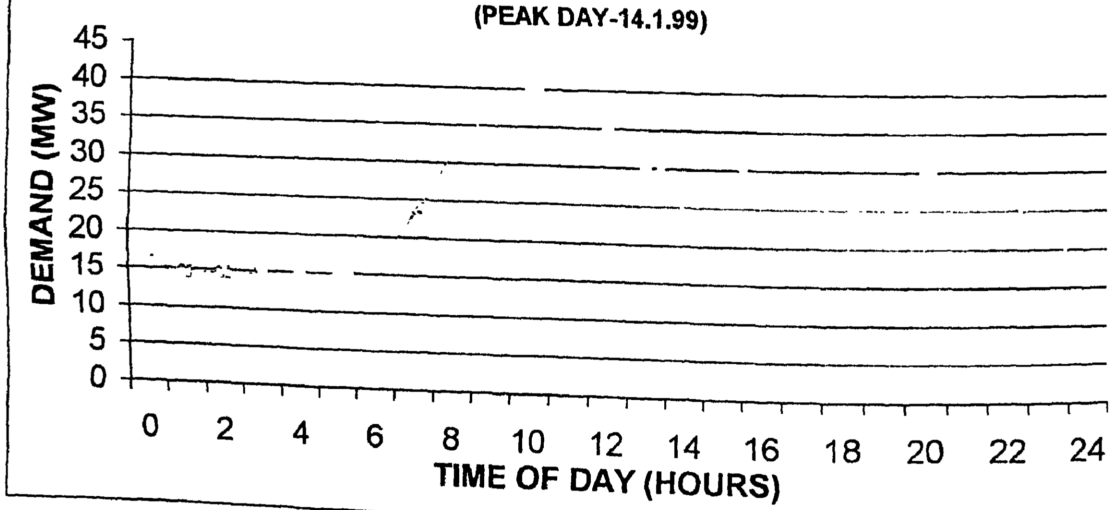


FIG.7(b) NEHRU PLACE 33/11 kV GRID S/S (PEAK DAY-14.1.99)



HOURLY LOAD PATTERN OF TWO Nos. INDUSTRIAL FEEDERS IN WINTER'98

FIG.8(a) OKHLA PHASE-I 66/11 kV GRID S/S(PEAK DAY-8.2.99)

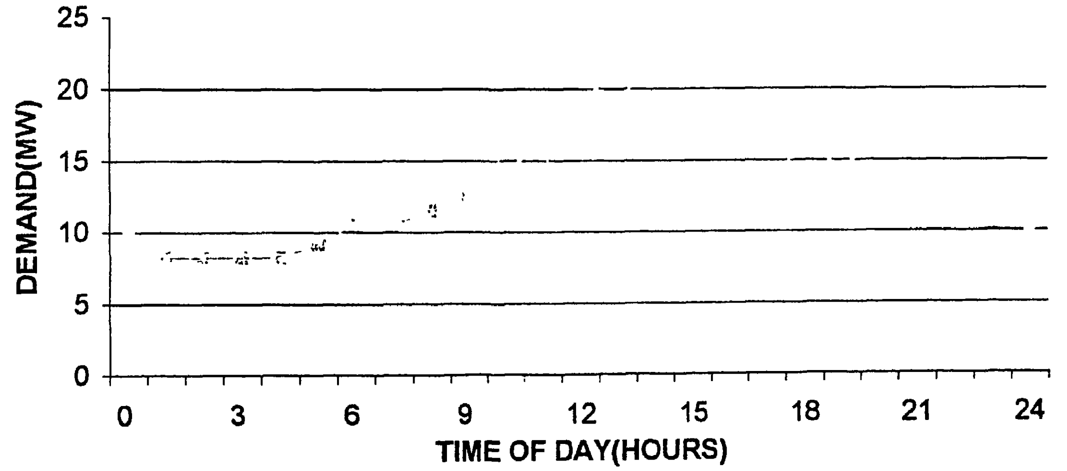
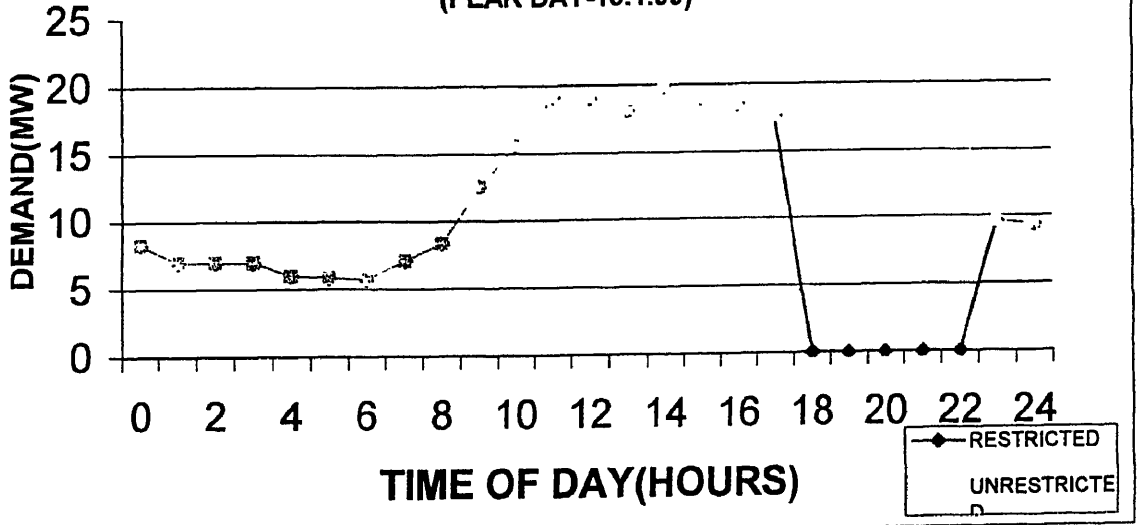


FIG.8(b)OKHLA PHASE-II 33/11 kV GRID S/S
(PEAK DAY-15.1.99)



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